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ATLAS AND EPITOME OF OPERATIVE SURGERY

BY
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114
Privat-docent in the University of Vienna

Second Edition, Revised and Enlarged
Authorized Translation from the German

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With 40 Colored Plates and 278 Illustrations in the Text

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PREFACE TO THE SECOND EDITION.

IN revising this work for a second edition the entire text has been subjected to a careful scrutiny, and many improvements and additions have been made. A number of the chapters have been practically rewritten, and of the newer operations, all those that appear specially valuable have been described.

The number of illustrations has been materially increased by the addition of sixteen lithographic plates in colors and the introduction of sixty-one additional figures in the text.

EDITOR'S NOTE.

DR. ZUCKERKANDL requires no introduction to English-speaking readers. In this Atlas he has laid down the rules and methods of surgical procedure with the clearness that springs from definite knowledge and the emphasis that is born of conviction. He describes lucidly and tersely the operations of modern surgery, and in a manner that fits the book to be a guide to the surgeon who operates upon the living or to the student who works upon the cadaver, the verbal descriptions being reinforced and illuminated by a large number of excellent original cuts.

The aim of the translator has been to portray the spirit rather than the exact words of the author.

In a very few places the editor has added notes that are explanatory in their nature, and are not to be considered as portions of the text.

PREFACE.

THIS epitome of operative surgery is intended as an elementary work for students in this subject. For this reason those groups of operations whose practice upon the cadaver forms the basis of practical instruction are described in detail and illustrated in their most conspicuous aspects. Other operations, whose performance falls largely to the lot of the skilled surgeon, and whose practice upon the cadaver appears less important, are described concisely. I am indebted to my collaborators, Mr. B. Keilitz, artist, and Mr. M. Silbermark, student of medicine, for the care that they have given to the illustrative portion of the book. The former has supplied the colored plates and the autotypes in the text; the latter has rendered material assistance in the execution of photographs, which have been reproduced as wood-cuts, as well as in the preparation of anatomic specimens.

THE AUTHOR.

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OPERATIVE SURGERY.

GENERAL CONSIDERATIONS.

(A) Division of the Tissues.

The **soft parts** may be divided by either bloody or bloodless means : by bloody means, with the *knife* or the *scissors* or by *puncture* ; by bloodless means, with the *actual cautery*, the *glowing* or the *cold wire-loop*, the *elastic ligature*, and the *écraseur*.

Bones may be divided with *chisel and mallet*, with the *saw*, with *bone-shears*, or *bone-forceps*, or with appropriate apparatus in special situations (*osteoclasis*).

The most important and the most generally used instrument of the surgeon, the *knife*, consists of a blade and a handle, which are either made of one piece or are articulated by means of an adjustable joint (*bistoury*).

In accordance with the form of the blade the following varieties of knives are recognized :

The bellied scalpel ;

The sharp-pointed knife ;

The blunt-pointed knife.

In the *bellied scalpel* (Fig. 3) the cutting-edge is convex, and the back straight and continuous with the handle of the knife.

The *sharp-pointed knife* is convex upon its back as well as upon its cutting-surface, terminating in a sharp point (Fig. 2).

The *blunt-pointed knife* is provided with a peripheral button-like extremity (Fig. 1).

FIG. 1.—Blunt-pointed knife.

FIG. 2.—Sharp-pointed knife.

FIG. 3.—Simple bellied scalpel.

FIG. 4.—Resection-knife.

FIG. 5.—Amputation-knife.

FIG. 6.—Tenotomes, with convex and concave cutting-edges.

FIGS. 7, 8.—Bistouries.

In accordance with the size and construction of knives further distinctions are made of *amputation-knives* (Fig. 5), *resection-knives* (short, strong knives, Fig. 4), *tenotomes* (Fig. 6), etc.

Division of tissues with the knife is effected by a combination of pressure and traction, the proper amount of each force employed being a matter of experience. Beginners often err in exercising only pressure with the cutting-edge of the knife.

For the division of the skin from the surface a simple bellied scalpel is used. This is grasped between the thumb, the index and the middle finger like a pen, the ulnar border of the little finger resting upon the operative surface, while the tissues to be divided are made tense with the fingers of the left hand (Fig. 9). This is the mode of holding the knife in making small cutaneous incisions and in free dissection of the tissues.

In making incisions of greater length the knife is held between the thumb and the pulps of the four fingers like a violin-bow, the tissues to be divided being made tense with the left hand. The operating hand is held free, without any support whatever (Fig. 10).

If the knife is to be carried, with a single stroke, through a thick layer of soft structures down to the bone, as, for instance, in exposing a joint, it is held like a table-knife and pushed through the soft tissues (Fig. 12). The division is effected by a sawing movement of the knife.

For the subcutaneous division of tendons the tenotome is grasped either between the thumb, the index and the middle finger (Fig. 13), or as an ordinary knife is held

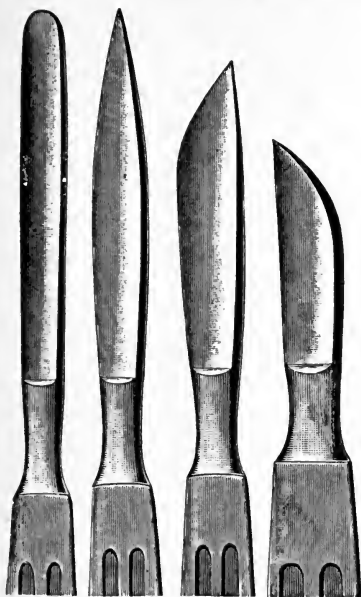


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.



FIG. 6.

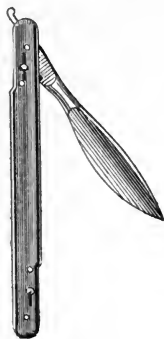


FIG. 7.

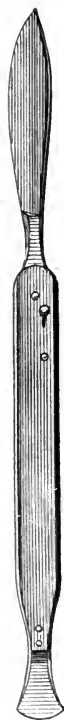


FIG. 8.



FIG. 5.



FIG. 9.—Knife held like a pen.

FIG. 10.—Knife held like a violin-bow.



in paring fruit, within four fingers, while the thumb is supported upon the operative surface (Fig. 14).

If the skin is to be divided *from within outward*, a sharp-pointed knife is used, which is passed at right angles through the base of a raised fold of skin and carried toward the surface of the skin (Fig. 11).

If a circular incision through the skin in the entire periphery of a part is to be made—for example, around the leg—the knife is grasped within the whole fist, with the cutting-edge applied at right angles upon the skin covering the surface of the extremity opposite to the side upon which the operator stands, being carried around

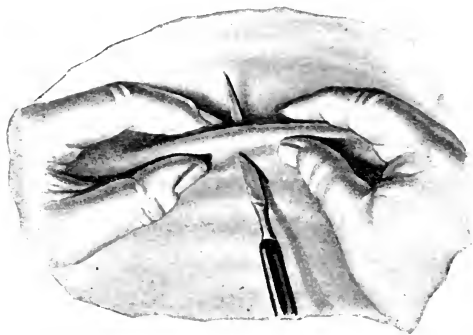


FIG. 11.—Division of a raised fold of skin from base to surface.

the extremity according to rules that will receive discussion later (see page 80).

In general, cutaneous incisions should sever the skin vertically. Oblique division of the skin is indicated only in certain cases.

Cutaneous incisions, in accordance with their form, are linear, semilunar, tongue-shaped (flap), T-shaped, H-shaped, or Γ -shaped, trapdoor-like, anchor-shaped (\perp), etc.

The length of the incision varies in accordance with the depth to which access is desired. In general, cutaneous incisions should not be too small, as longer inci-

sions permit careful inspection of deep-seated structures, and are thus more convenient and also more conservative.

Deep Dissection.—Accurate surgical dissection consists in attaining the desired end, the exposure or the enucleation of a structure, with most complete protection possible of adjacent tissues. Structures that obstruct the

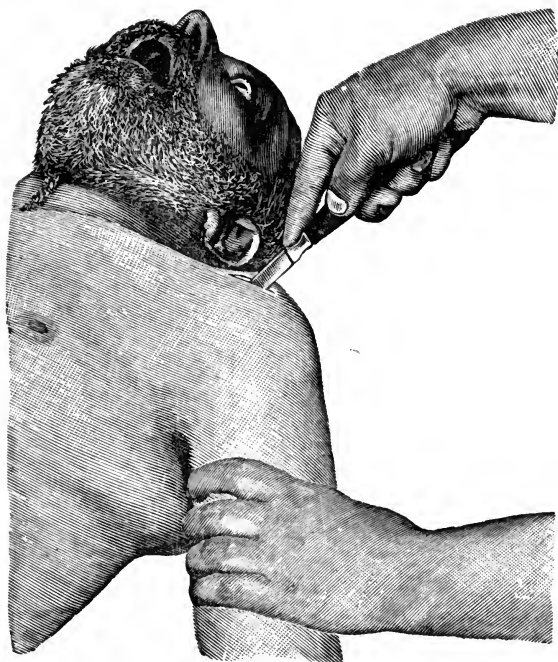


FIG. 12.—Mode of using the resection-knife.

field of operation may be displaced by means of retractors or tenacula (blunt, sharp, with one or more teeth); nerves and vessels should never be grasped between the blades of forceps, but should always be carefully displaced with the aid of blunt retractors. If a blood-vessel be in the way, it may be secured with two ligatures and divided

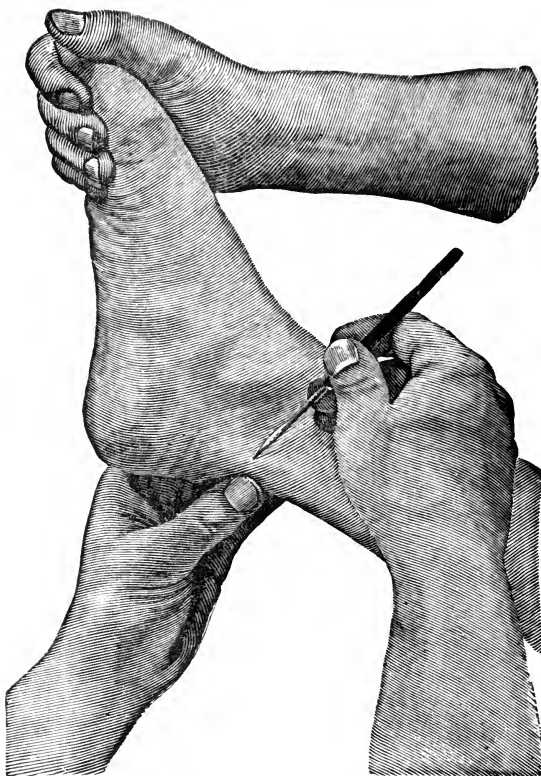


FIG. 13.—Mode of using the tenotome.



FIG. 14.—Mode of using the tenotome.

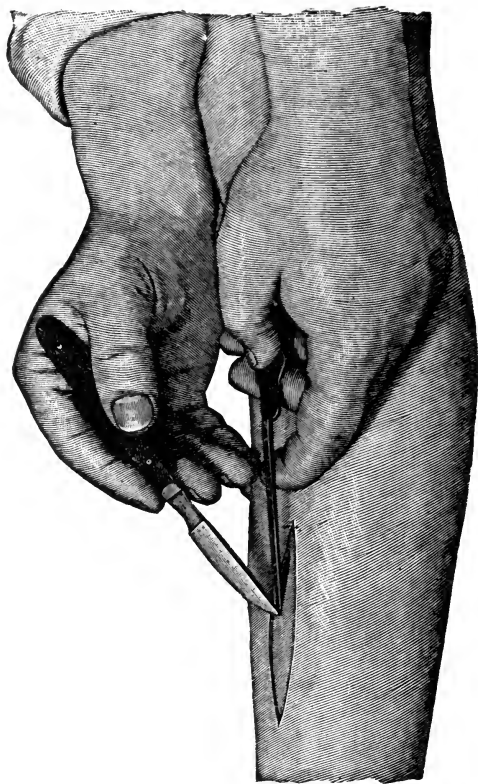


FIG. 15.—Division of tissues with the aid of the grooved director.

between these. In order to practise deep dissection safely several methods may be pursued :

- (1) Free dissection,
- (2) Dissection with the aid of the grooved director,
- (3) Dissection between two pairs of forceps,
- (4) Blunt dissection.

Free dissection with the scalpel requires anatomical certainty and skill in the use of the knife, which is held like a pen.

Dissection with the aid of the grooved director is to be recommended when in the course of deep operations the anatomical relations permit the tissues to be separated layer by layer. It is applicable in the performance of herniotomy, in the open operation for hydrocele, in division of the abdominal walls, etc. With a pair of anatomic forceps held in the left hand a small cone of the tissue to be divided is raised up and slit open at its base with a knife. Through the opening thus made a grooved director is introduced, with its groove directed upward, and pointed in the direction of the proposed incision. The groove of the director serves as a guide for the back of the knife in making the incision (Fig. 15).¹

In *operating between two pairs of forceps* the operator and his assistant pick up successively at opposite points the tissues to be divided, and the fold of skin thus raised is incised between the two instruments (Fig. 16). This mode of procedure is applicable in opening the abdominal cavity and in the performance of herniotomy.

Blunt dissection for the isolation of structures in loose cellular tissue is accomplished by pushing the tissues back with two pairs of anatomic forceps and thus avoiding hemorrhage. This method is especially indispensable in the exposure of vessels and nerves and of the trachea.²

If a considerable layer of muscular tissue is to be

¹ It is rarely advisable to use a grooved director. It lacerates parts, gives irregular incisions, and hence militates against primary union. A surgeon rarely finds the instrument necessary.—Ed.

² In accomplishing blunt dissection the Allis dissector is of the greatest value.—Ed.



FIG. 16.—Dissection between two pairs of forceps.

divided by the first incision, a strong, short, resection-knife is used. This is grasped like a table-knife, and pushed vigorously through the soft structures down to the bone, when, with sawing movements, thick layers of muscle may be divided (Fig. 12).

For circular division of masses of muscle the knife is held within the whole fist and used according to certain rules (see page 82).

If a band in the depth of a wound and not accessible to the eye, or a constricting ring, is to be divided, this is usually effected by means of the blunt-pointed knife or herniotome under guidance of the finger. The blunt point protects the tissues from injury when the knife is intro-



FIG. 17.—Mode of using the blunt-pointed knife.

duced, as well as the pulp of the left index-finger, upon which the knife is supported. After the precise point at which the incision should be made has been determined by means of the introduced index-finger, the blunt-pointed knife is grasped like a pen and, with its back supported upon the palmar surface of the index-finger, is introduced into the depth of the wound. The division is effected through the pressure exerted by the finger upon which the knife is resting (Fig. 17).

Division with Scissors.—The scissors is used for the division of band-like structures, tendons, muscles, vessels; also certain structures that, on account of their

consistency, are unsuitable for division with the knife. Thus, for instance, the yielding intestinal tissues, when resected, are divided by the scissors. The scissors may be used alternately with the knife in the dissection of tissues.¹ The blunt blade of the scissors is introduced beneath the layer of tissues to be divided.

Scissors with straight blades or scissors curved upon the flat are employed. In using the scissors the thumb

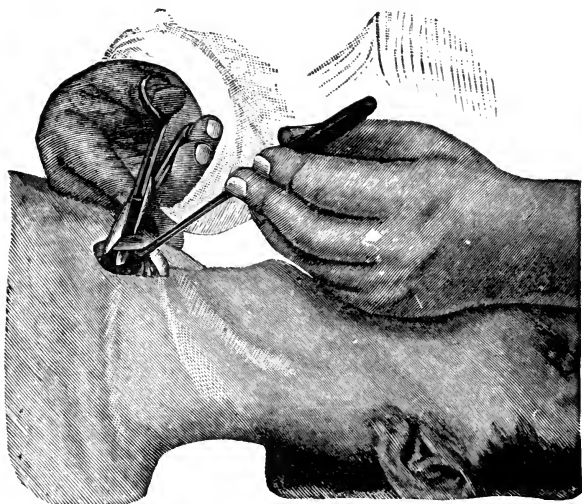


FIG. 18.—Division with scissors.

and the middle finger are introduced into the rings of the handles and the index-finger is placed upon the lock (Fig. 18).

The tissues to be divided are caught between the blades of the scissors, division being effected by the movement of the blade held by the thumb against the other, which is grasped firmly.

¹ The scissors is very useful in enucleating dermoid cysts, sebaceous cysts, adherent fatty tumors, bursæ, and fibromata.—ED.

Division of Tissues by Puncture.—Division of tissues by puncture is practised when fluid is to be evacuated through a cannula introduced into pathological or physiological cavities (puncture of abscesses, of hydrocele); or when a sharp, hollow needle is employed to introduce fluid into the cellular tissue or into the parenchyma of organs (*subcutaneous, parenchymatous injections*). Exploration in the depth of the tissues with the introduced needle is at times necessary for diagnostic purposes. Finally, in the introduction of sutures, the establishment of puncture-canals is necessary.

For puncture, straight or curved tubular instruments (trocars) are required, which are provided with a stilet, whose sharp extremity projects a slight distance beyond



FIG. 19.—Mode of using a trocar.

the end of the tube. In making a puncture the trocar is so held in the full fist that the handle of the instrument rests in the hollow of the hand, the index-finger marking the point upon the shaft to which it may enter (Fig. 19).

With a vigorous push the instrument is forced vertically through the skin in the selected situation and into the cavity. The entrance of the trocar into the cavity is indicated by a change in the sense of resistance. The cannula is now grasped at its extremity with the thumb and the index-finger of the left hand and the trocar is withdrawn.

Puncture made with slender instruments for diagnostic purposes is known as exploratory puncture. The escape of the contents through the slender tube of the cannula

must often be aided by aspiration by means of an attached syringe.¹

For the purpose of making subcutaneous injections a fold of skin is raised and the needle of the syringe is introduced horizontally through the skin into the subcutaneous cellular tissue, into which the fluid is forced by pressure upon the piston of the syringe.² In making parenchymatous injections the needle of the syringe is introduced directly through the skin into the interior of the organ (thyroid gland, lymphatic glands).

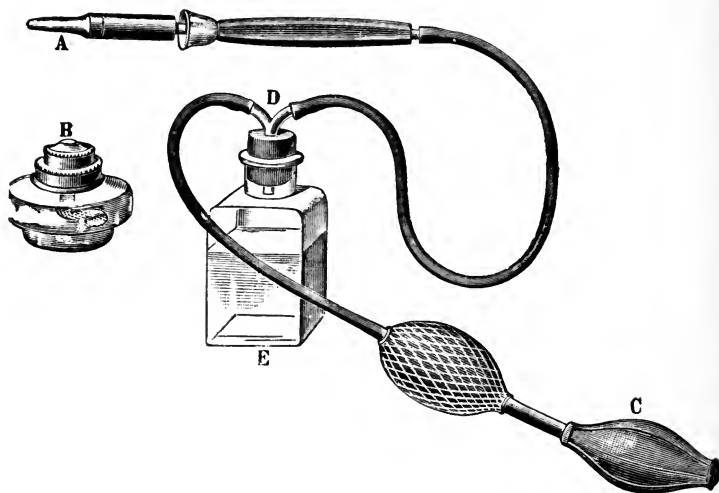


FIG. 20.—The thermocautery of Paquelin: *A*, tip; *B*, spirit-lamp; *C*, rubber air-bulb; *D E*, reservoir for benzine.

Bloodless Methods of Dividing Tissues.—(1) The *actual cautery*, consisting of an iron rod brought to a

¹ The old grooved exploring-needle has been generally abandoned in favor of the hollow needle. The former instrument is unsafe if infective material is withdrawn by it, as the fluid comes in contact with the canal of puncture and will probably infect it.—Ed.

² After introducing the needle it should be moved from side to side to see that it is free and to be certain it has not entered a blood-vessel.—Ed.

JK

glow in the fire, finds no application in this crude form in



FIG. 21.—Wire loop (snare).



FIG. 22.—Écraseur.

modern surgery, although tissues may be divided without loss of blood by means of the glowing extremity of the

thermocautery of Paquelin (Fig. 20), or with a platinum wire brought to a glow by means of an electric current (*galvanocautery*). The extremity of the thermocautery brought to a red heat in the flame of an alcohol lamp can be kept in a continuous glow by means of a fine spray of petroleum-ether. By regulating the stream of petroleum-ether vapor—that is, by more or less energetic manipulation of the air-bulb attached to the apparatus—all degrees of incandescence up to white heat may be secured.

By means of the various kinds of *loops* or *snare* tissues may be separated at their base if they be so constituted that the loop can be made to surround the line of division. The *galvanocaustic snare* brought to a glow by means of an electric current and gradually tightened divides the tissues without loss of blood.

The *simple wire snare*, which crushes directly through the tissues, can be employed only in the removal of structures of slight resistance—for instance, nasal polypi. The tightening of the loop is effected by means of a suitable screw-attachment (Fig. 21).

The *elastic ligature* (Dittel), an India-rubber band tightly wrapped around the tissues to be divided, operates through the continuous pressure exerted and cuts its way through gradually in the course of days or weeks. The process is so gradual that the surface exposed after separation represents a simple granulating wound. The elastic ligature may also be employed successfully in the severance of dense fibrous pedicles of considerable extent, as in the removal of some uterine myomata.

Écrasement, the crushing of tissues with the aid of a linked chain, was employed in large numbers of cases during the middle of the last century. The *écraseur* of Chassaignac (Fig. 22) permits of quite gradual tightening of the chain, which is withdrawn link by link within the shaft of the instrument. *Écrasement* has been almost totally displaced by the galvanocautery and the thermocautery, and the procedure survives only by reason of its brilliant past.

Division of Bone.—This is effected with the aid of the saw, chisel and mallet, bone-shears, and bone-forceps.

Bones are broken subcutaneously either manually, or with the aid of special apparatus (osteoclasts).

Bloody division of bone should always be preceded by division and detachment of the periosteum in the area of intended operation.

The *arched saw* (Butcher's) (Fig. 23) is used whenever the conditions permit of free movement of the instrument,

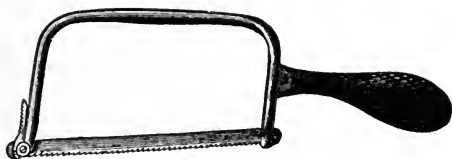


FIG. 23.—Arched saw (Butcher's).

as in division of the bones of the extremities in the course of amputations and of the articular extremities in the course of resections.

In the use of the arched saw care should be taken that the instrument is held accurately in the plane of intended

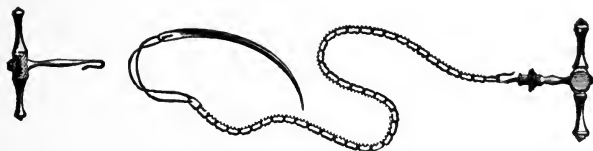


FIG. 24.—Chain-saw.

division. The saw is at first applied very gently, almost no pressure being made, greater force being employed only after a groove has been formed for the blade of the instrument.

If the bone to be divided is so situated that free movement of the arched saw is likely to be interfered with, as in division of the lower jaw, of the zygomatic process of the upper jaw, etc., the *chain-saw* (Fig. 24) or the *wire saw* may be employed with advantage. The former (Fig. 24)

consists of a series of toothed links united by joints; the *wire saw* (Fig. 25) consists of coarse metallic wire, the

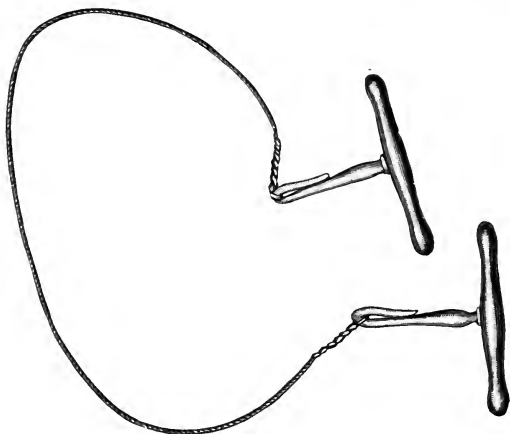


FIG. 25.—Wire saw.

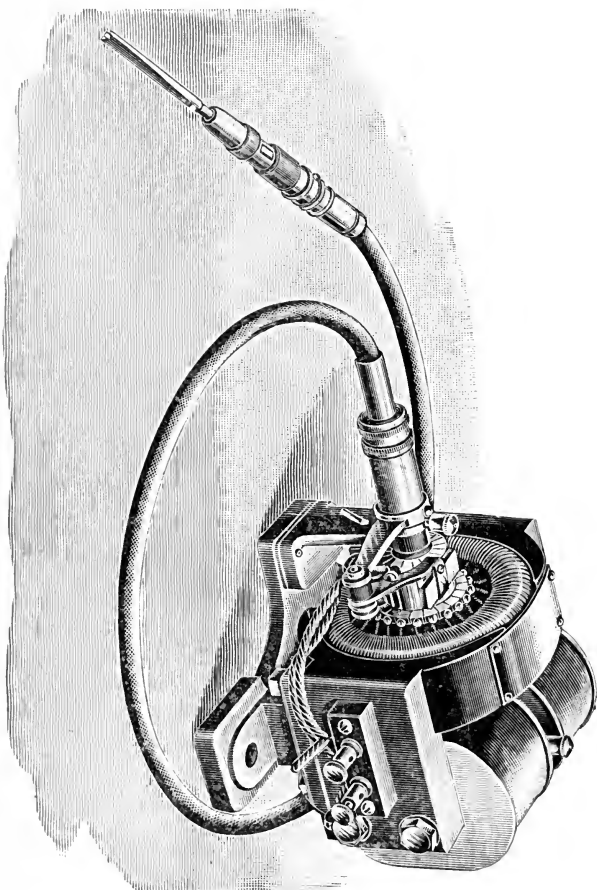
extremities of which, as in the chain-saw, are provided with openings for the attachment of appropriate handles. These filamentous saws are made, often with the aid of a curved needle, to surround the bone to be divided, when, by means of the handles, and with the saw drawn tense, the division of the bone is effected by sawing movements.

Of late it has become customary to use forms of *circular saws* (Fig. 26) in resection of the bones of the skull. The instrument is best driven by means of an *electric motor* (Fig. 27). It operates rapidly and with precision, and any considerable concussion of the bone is avoided in the division—an important consideration in operations upon the skull.



FIG. 26.—Circular saw.

FIG. 27.—Electromotor for driving the circular saw.



Chisel and mallet likewise are often employed in operations upon the bones of the extremities, as in linear osteotomy, chiseling of necroses, etc. They are less well adapted to resections of the bones of the skull.

Thin bony structures, as the ribs and the phalanges, projecting splinters upon sawn surfaces, may be divided by means of *bone-shears* or *bone-forceps*.

To freshen bone-surfaces the *sharp spoon* and *strong knives* may be used with advantage.

Osteoclasis, the breaking of bone, may be undertaken for orthopedic reasons in cases of badly united fractures and of deformities of the extremities, either manually or with the aid of apparatus (osteoclaster). Manual osteoclasis is attended with the disadvantage that the fracture may fail to take place exactly in the desired situation. Useful forms of osteoclaster have been devised by Rizzoli and by Robin. That of the latter is constructed upon the principle of the one-arm lever, and permits the breaking of the bone with the slightest possible injury of the overlying soft structures.

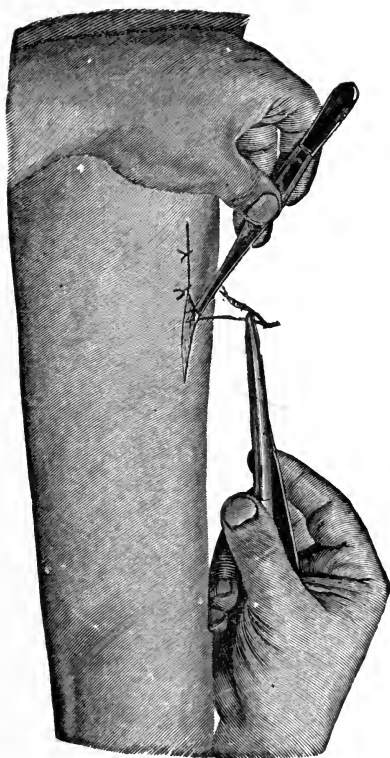
(B) Reunion of the Tissues.

The closing of a wound has for its object the firm and unyielding approximation of the several layers of the wound throughout the period of healing. Such approximation may be effected shortly after the reception of the injury (*primary suture*), or at a time when the wound has entered upon the stage of granulation (*secondary suture*).

Bloodless approximation of divided tissues by means of adhesive agents, such as collodion or adhesive plaster, is applicable only to cases of exceedingly slight injury, without considerable separation of the margins of the wound—for instance, to skin wounds. Wounds of greater extent, if capable of primary union, should always be closed by *sutures*.

By means of curved needles (Fig. 33) threads are passed through the lips of the wound and tied. The su-

FIG. 28.—Introduction of the needle.



ture is introduced at right angles to the direction of the wound, passing through corresponding points on opposite sides. The needles are passed either with the free hand or are grasped and directed by forceps-like instruments—needle-holders (Fig. 28). In so-called handled needles the needle and its holder form a continuous instrument.¹

Silk, catgut (absorbable), and metallic wire (silver, lead) are used as suture-material.²

If the wound be but superficial, approximation of the margins of the skin with sutures will be sufficient, the needle being introduced in general at a greater or lesser distance from the margin of the wound, in accordance with its depth.

In order to avoid the formation of cavities in the closure of deep or sinuous wounds it is wise either to unite the tissues in the depth of the wound (buried suture) or to approximate extensive surfaces of the wound.

If the wound be a complicated one, muscles, tendons, and nerves being injured, these structures must be severally isolated and united before closure of the wound is proceeded with.

In the closure of cutaneous wounds the *simple knotted silk (interrupted) suture* is sufficient (Fig. 29). By the introduction of deep and superficial sutures the endeavor is made to secure as perfect approximation as possible of the surfaces of the wound and margins of the skin. Inversion of the latter is to be avoided by accurate approximation of the margins of the wound.

The *continuous suture*, a single thread being employed without interruption, is also available in the union of cutaneous wounds. It is applied in various ways, as in the simple continuous suture (Fig. 30), as the glover's suture (each loop being tied separately, but not cut apart—Fig. 31), and as the mattress-suture (running back and

¹ In the United States many surgeons use Hagedorn needles. For intestinal work small, sharp, round sewing-needles are employed, preferably calyx-eyed, which are easily threaded.—Ed.

² Silkworm gut is very frequently employed. Pagenstecher's celluloid silk is sometimes used, and so is chromic catgut.

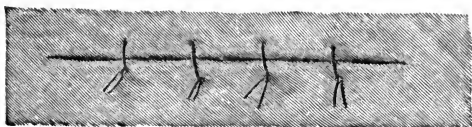


FIG. 29.—Simple knotted (interrupted) suture.



FIG. 30.—Simple continuous suture.

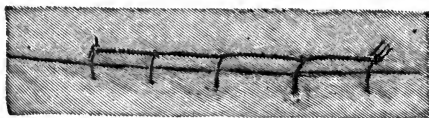


FIG. 31.—Glover's suture.

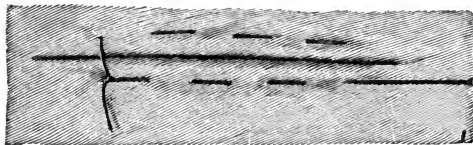


FIG. 32.—Continuous mattress-suture.



FIG. 33.—Varieties of surgical needles.

forth through both lips of the wound—Fig. 32). The mode of introduction is illustrated in the accompanying figures.

When extensive areas of wound-surface are to be brought in approximation, deep sutures are employed, both extremities of the thread being armed with either lead plates (Lister) or small pads of gauze (Wölfler) (Fig. 34). As the suture, thus applied, may be drawn firmly

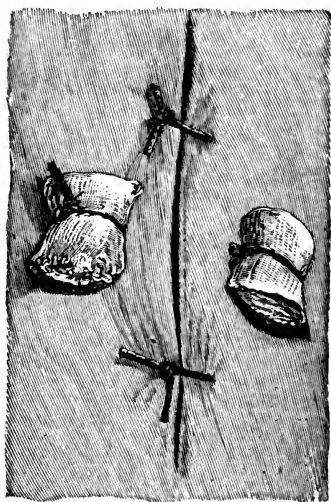


FIG. 34.—Gauze-pad suture.

together and be securely fixed, it is possible to bring the margins of the wound in contact throughout a considerable extent. Intercalated knotted sutures will insure exact approximation of the margins of the wound. In using Lister's lead-plate suture, wire is employed as the suture-material, the fixation being effected by means of small perforated lead buttons, which are drawn over the wire, then pressed flat with a pair of forceps, and thus securely fixed.

Divided muscles are united with interrupted sutures of



FIG. 35.—Paratendinous suture.

silk or catgut in such a manner that the cut surfaces are brought together in accurate apposition.

In uniting *divided tendons* also the cut ends should, so far as possible, be brought in apposition. In the union of flat, band-like tendons—for instance, the extensors on the dorsum of the hand and on the extensor aspect of the fingers—the divided ends may be overlapped and thus sutured. Hüter recommended the employment at once of this so-called *paratendinous suture* (Fig. 35) in all instances.

Strong, thick tendons, such as the flexors of the fingers, the tibialis anticus and posticus, the peronei, etc., may, when divided, be united by simple knotted fine silk sutures applied in a longitudinal direction. To prevent cutting through of the sutures these may be advantageously passed at right angles through the divided extremities (Fig. 36).

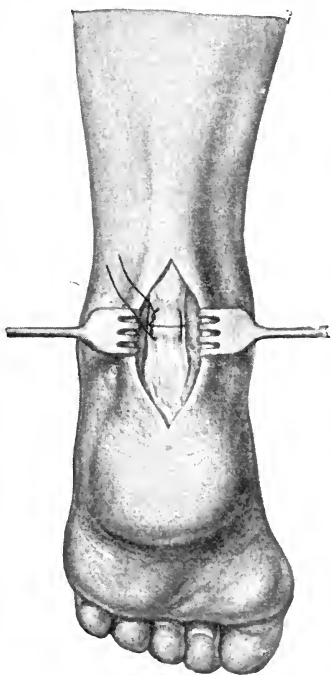


FIG. 36.—Transfixion of divided tendon by suture.

The application of supporting loops of thread, which are subsequently tied together, is also a useful procedure (Fig. 37).



FIG. 37.—Ends of divided tendon held by supporting loops.

Before suture of a tendon is undertaken preliminary operative procedures, such as division of the skin and of the sheath of the tendon, are sometimes necessary in order to secure the central extremity of the tendon. The same end may often be attained by centrifugal bandaging of the part, or with the aid of a sharp tenaculum. After the tendon has been united by suture it is important so to place the extremity operated upon in its dressing that the tendon may be maintained in a position of greatest possible relaxation until firm union has taken place.

If by reason of separation of the extremities of a divided tendon approximation cannot be effected in the usual manner, the continuity of the tendon may be established by means of an auxiliary operation, tenoplasty. From the side of one of the extremities of the divided tendon a small portion is so freed that it can be turned over toward the other extremity, with which it is united by suture (Hüter) (Fig. 38).¹

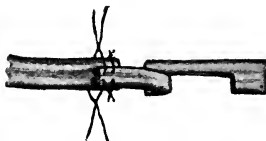


FIG. 38.—Hüter's tenoplasty.

Nerve-suture, as first practised by Robert and Nélaton, may be employed in cases of recent injuries attended with division of nerves, as well as a secondary procedure after isolation and freshening of the divided extremities. The object of nerve-suture is the approximation of the

¹ Instead of silk, kangaroo-tendon or chromic gut can be employed.—Ed.

transverse edges of the divided nerve-strand. To this end either fine threads are passed directly through the substance of the nerve, and the transverse surfaces of the divided extremities are brought in apposition, or the extremities are so united that they overlap one another upon their lateral surfaces (*paraneural suture*).

The extremities of the divided nerve may be so united that the sutures are not passed through the substance of

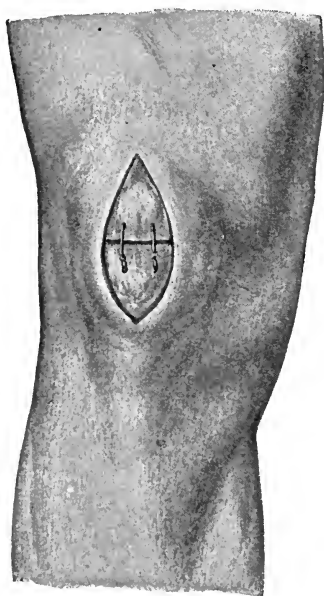


FIG. 39.—Suture of the patella with wire.

the nerve, but through the surrounding connective tissue. In this way the extremities of the cut nerve are indirectly approximated (*perineural suture*).

Neuroplasty, based upon the same principle as the tenoplasty of Hüter, may also be employed successfully in the union of divided nerves.

The position and fixation of the extremity operated upon should be such as to prevent all disturbance of the nerve after the operation.

The *union of bones* may be aided by suture in the same manner as are wounds of the soft tissues (Fig. 39), except that wire is employed with especial advantage as suture-material. The channels for the passage of the sutures must be made by means of a drill or an awl. The wires are fastened by twisting their extremities together. Braces or clamps also may be employed in the same way as they are used in securing boards in scaffolding (Gussenbauer's clamp (Fig. 40)).¹

Severed bones may further be united by means of nails or ivory pegs (Fig. 41). Nails may also be driven into



FIG. 40.—Bone-brace.



FIG. 41.—*a*, metallic nail ;
b, ivory peg.

the bone through the overlying soft tissues in order to maintain the fragments in apposition (*percutaneous nailing of bones*).

Metallic sutures, pegs, and nails are to be removed only after the lapse of weeks, when firm union of the divided bone has taken place.²

¹ Parkhill's clamp is very useful.—ED.

² The ends of a broken bone may be held together by a silver plate and screws or by Senn's ferrules of decalcified bone.—ED.

I. OPERATIONS ON THE EXTREMITIES.

1. Ligation of Vessels in Continuity.

An injured and bleeding vessel may be seized directly within a wound and the hemorrhage controlled by ligation. Another mode of procedure consists in exposure of the divided vessel above the wound for the purpose of its ligation. This variety of ligation of vessels in continuity will now be considered.

Indications.—(1) **Injuries.**—(a) *Stab-wounds, gunshot-wounds, contused wounds, and lacerated wounds* of the large arteries. If possible, ligation is to be undertaken at the site of injury. This is difficult in lacerated tissues suffused with blood, when the wound is unfavorably situated, or when the artery is injured directly at its origin from a main branch.

(b) *Subcutaneous laceration* of large vessels; also when ligation at the site of the lesion is impossible.

(2) **Hemorrhages** from suppurating wounds through erosion of large vessels; further arterial hemorrhage from gangrenous tissues or disintegrating new-growths.

(3) In order to render an operation bloodless the main arterial branch of the operative area may be previously ligated—*e. g.*, the lingual artery preceding extirpation of the tongue, the femoral artery preceding enucleation of the hip-joint, and preceding extirpation of cavernous tumors.

(4) In order to induce involution of morbidly altered organs or neoplasms the blood-supply may be cut off by ligation of the main artery—*e. g.*, of the thyroid artery in the presence of goiter, of the spermatic artery in the presence of tumors of the testicle, of the internal iliac arteries in the presence of hypertrophy of the prostate, etc. In the same category belongs the treatment of *elephantiasis of the leg* by ligation of the external iliac or the femoral

artery, with the aid of which some surgeons have secured good results.¹

(5) **Aneurysms.**—Hunter's method of treatment consists in ligating the afferent artery, a branch or branches intervening between the ligature and the sac. On account of the return supply of blood to the aneurysmal sac through the collateral circulation this method is less reliable than that of Antyllus.

In cases of *trigeminal neuralgia* resisting other operative measures, ligation of the carotid artery has been repeatedly practised (Pátruban).

The treatment of *epilepsy* by isolation and ligation of the vertebral artery has been more recently proposed.

Method of Ligation.—At definitely determined points upon the surface of the body the skin is divided and with careful protection of important structures the sheath of the vessel is exposed. This is then opened, and the artery, separated from the accompanying veins for a small portion of its extent, is raised from its bed for the purpose of ligation. Two ligatures are now applied, and the artery is divided transversely between them with a single cut of the scissors. The wound in the skin is closed by suture.

The *cutaneous incisions* are made in selected situations in a definite direction so-as to render possible access to the artery by the shortest route. Usually the incision in the skin corresponds with the course of the artery. Thus, in the extremities this incision, with a few minor exceptions, coincides with the longitudinal direction of the parts.

In order that the incision in the skin may be placed in the proper situation, it is necessary to make careful scrutiny of the surface of the body. To facilitate this, prominent, readily palpable points of the skeleton, as well as muscular

¹ In some regions extirpation of a vessel is better than ligation, if we wish to arrest the growth of a tumor. Dawbarn has recently pointed out that ligation of the external carotid is of slight value in sarcoma of the tonsil, as the anastomotic circulation is so quickly established, but extirpation of this vessel causes great shrinking of the growth. We have verified this observation.—ED.

prominences, and the intervening depressions, are selected as landmarks.

The length of the cutaneous incision will be regulated by the depth to which access is desired: the deeper the wound the larger must be the opening in the skin. The incision for exposure of the internal iliac artery will measure from 15 to 20 cm. (6 to 8 in.), while that for the radial artery at the wrist-joint need not be more than 1 or 1.5 cm. ($\frac{1}{3}$ or $\frac{1}{2}$ in.).¹

When the skin and the subcutaneous connective tissue have been penetrated (the base of the wound is no longer moved with movements of the margins of the skin), the sheath of the vessel is carefully approached by dissection with the free hand, between two pairs of forceps, or with the aid of the grooved director. Muscles, nerves, and veins that obstruct the way are displaced with blunt hooks. If a vessel prevents access to the artery, it may be ligated in two places and divided between.

The *sheath of the vessel* is detached from the artery for a short distance by blunt dissection with anatomic forceps, or it is divided upon the grooved director, in accordance with the character of the tissues. After the sheath has been opened, either a single vessel will be exposed or both artery and vein will come into view. The most reliable guides are furnished by the topographic-anatomic relations. The artery must be recognized as such from its situation, as all other means of identification may under circumstances fail. The color of the vessel is as little distinctive as is the thickness of its walls, as both arteries and veins may possess the same color in the dead subject in consequence of imbibition, while the thickness of the wall of the vessel is subject to wide individual variations. As a rule, however, the walls of the arteries are thicker than those of the veins, although not rarely in enfeebled individuals, and particularly in females, the arteries are small and thin-walled. It might be supposed that during life

¹ Operation through a very small incision is often possible, but it is a needless effort and is unsafe for a beginner.—ED.

pulsation of the vessel would be an infallible means of recognizing the arteries; but this is not always so, as arteries may at times exhibit no pulsation after free loss of blood, while, on the other hand, veins may apparently pulsate through transmission of movement from the arteries. The anatomical relations therefore are the only reliable guides for distinguishing between artery and vein.



FIG. 42.—Artery divided between two ligatures.

When the sheath of the vessel has been opened and the artery brought into view, this must be isolated with two pairs of forceps for a distance of 1 or $1\frac{1}{2}$ cm. ($\frac{1}{3}$ – $\frac{1}{2}$ in.) and raised from its bed for the application of the ligature. To this end one lip of the opened sheath is grasped with a pair of forceps held in the left hand, and traction is

made, while with the blades of the other pair of forceps the loose tissue surrounding the artery is detached in its longitudinal direction. From time to time the fixing and the dissecting hand are alternated, care being taken to avoid inclusion of the artery, of a vein, or of a nerve between the blades of the forceps. From the side of the artery next which lies the vein [or rather the most dangerous neighbor, for in some situations the nerve must be avoided rather than the vein.—ED.], the ligating instrument, armed with a ligature, is passed beneath the artery, and the ligature wound about the vessel and tied. A second ligature is applied in a similar manner at about a distance of 1 cm. ($\frac{1}{3}$ in.) from the first, and, between the two, the artery, raised from its bed, is cut squarely with a single stroke of the scissors. The divided ends of the vessel retract somewhat in either direction (Fig. 42). The application of two ligatures and cutting between possess some advantages, but are not always necessary.

The retraction and the relaxation of the extremities of the divided vessel afford more favorable conditions for thrombus-formation, through narrowing of the lumen, than simple occlusion of the lumen of the vessel. Besides, by division of the vessel between the ligatures, a view is obtained of the posterior wall of the artery, and in this way ligation of the artery just in advance of or just beyond the origin of a lateral branch can be avoided. Either contingency is equally unfavorable to thrombus-formation. The small wound made is closed with interrupted sutures.

The *knot of the ligature is tied* as follows: after the ligature has been made to surround the artery the free end on either side is grasped with the fingers of the corresponding hand. Before the knot is tied the ends are so crossed that the right passes behind the left and is received into the left hand, while the left passes in front of the right and is received into the right hand. When the extremities have been thus crossed a simple knot is tied. Before the second knot is placed upon the first the free extremities must again be changed and in such a manner

that that upon the left is passed in front of that upon the right. The *sailor's knot* or reef knot (Fig. 43) thus formed is more secure than the ordinary *granny's knot* (Fig. 44).

If in the first part of the knot the extremities are twisted twice, instead of once, there results the so-called *surgical knot* (Fig. 45).

The sailor's knot is employed not only in the application of ligatures, but whenever it is desired to tie a secure knot.¹

Ligations in the Upper Extremity.—The artery supplying the arm, the forearm, and the hand may be

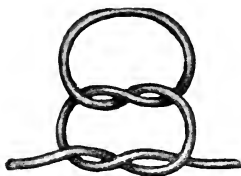


FIG. 43.—Sailor's knot [reef-knot].

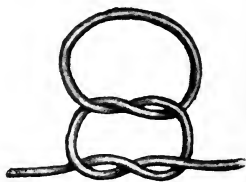


FIG. 44.—Granny's knot.

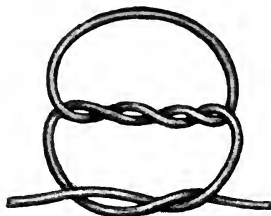


FIG. 45.—Surgical knot.

exposed in a typical manner for purposes of ligation in the axilla, upon the upper arm, at the flexure of the elbow, and upon the forearm.

The *axillary artery* is the continuation of the subclavian from the lower border of the first rib to the surgical

¹ The first knot is tied with some force, the second knot firmly but not forcibly. To tie the second knot forcibly is apt to cause breaking of the ligature. The force used to tie a ligature must be steady, never in jerks.—Ed.

neck of the humerus. When the arm is abducted, it lies in intimate relation with the bone; below the pectoralis minor the vessel lies in contact with the coracobrachialis. Of the branches of the brachial plexus, only the median nerve is situated in front of the artery, the axillary vein lying toward the middle line and at a more superficial level.

Ligation of the Axillary Artery in the Lower Third of its Course.—The body occupies the dorsal decubitus, with the

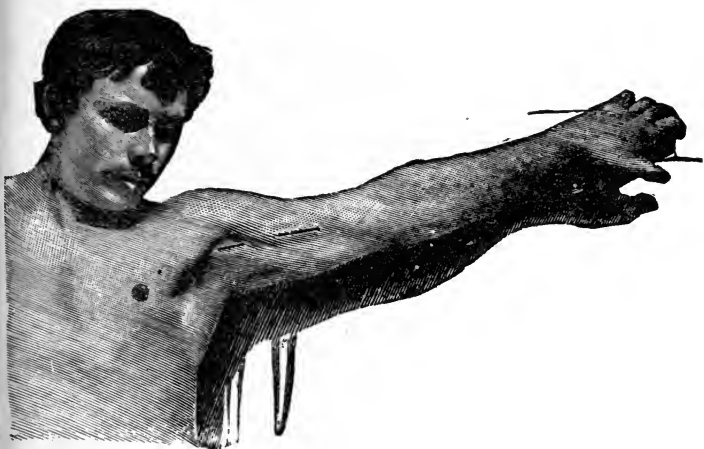


FIG. 46.—Axillary cavity: incisions for exposure of the axillary artery and the brachial artery.

arm abducted and held at a right angle to the trunk in such a manner that the extended forearm assumes a position midway between pronation and supination. The operator stands between the thorax and the abducted arm, the assistant to his left. The axillary cavity is exposed to view, with its boundaries, the anterior (border of the pectoralis major) and posterior axillary folds (border of the latissimus dorsi and teres major), between which, when the arm is abducted, the skin occupies the concavity of the

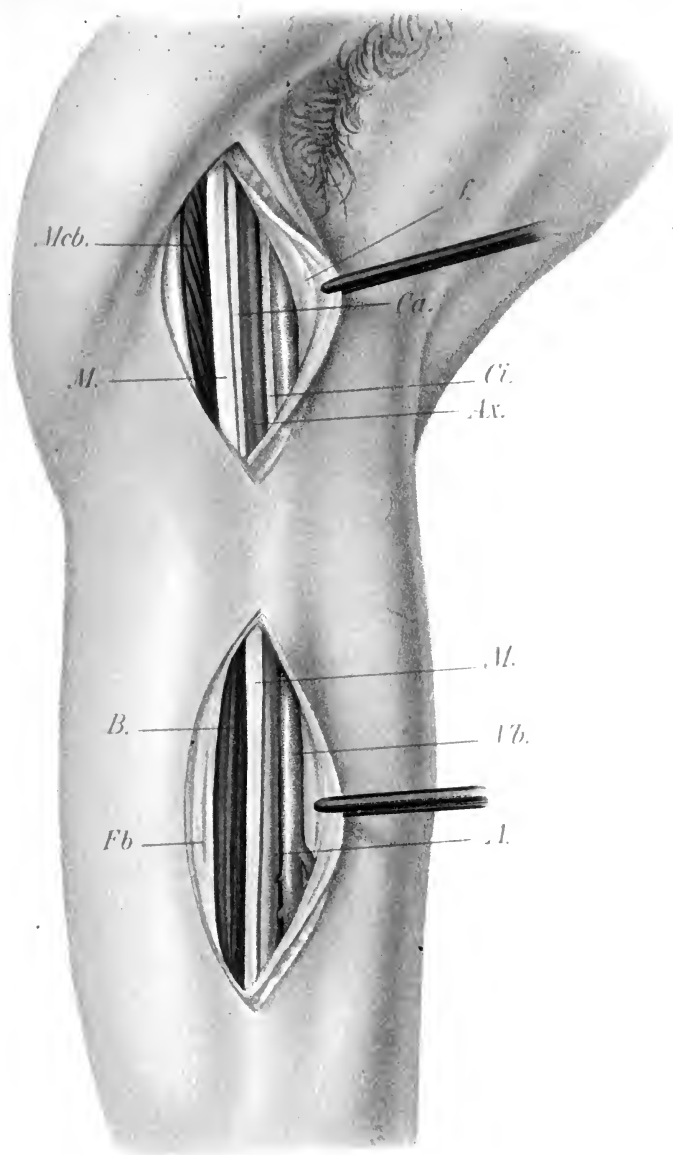
Plate 1.—Exposure of the Axillary Artery and the Brachial Artery (Right Arm).

Mcb, coracobrachialis; *f*, inner portion of the fascia of the upper arm; *M*, median nerve; *Ci*, lesser internal cutaneous nerve; *Ca*, greater internal cutaneous nerve; *Ax*, axillary artery; *B*, biceps; *Fb*, brachial fascia. *A*, brachial artery. *Vb*, brachial vein.

axilla. In the latter the prominence of the head of the humerus is both visible and palpable. Upon the arm, whose inner aspect is directed toward the operator, is the internal bicipital sulcus, running parallel with the arm between the bellies of the biceps and the triceps. This groove forms the main bed of the vessels and nerves of the arm. It does not extend quite to the anterior axillary fold, as the belly of the biceps diminishes in size at this point before passing over into the tendon. The border of the pectoralis major and the upper extremity of the biceps form here two sides of a triangle whose base is completed by the coracobrachialis (Fig. 46). This triangle, formed by the elevations of three muscles, is the situation in which the artery is to be exposed.

It would be a mistake to look for the vessel in the axillary cavity, which forms a space filled with fat, connective tissue, and lymphatic glands next to the lateral wall of the chest. The artery, which lies close to the humerus, is therefore to be looked for in relation with this bone at the apex of the axillary cavity.

The incision is made along the line of the coracobrachialis muscle in the continuation of the internal bicipital sulcus (Fig. 46). After the subcutaneous connective tissue has been passed the thin fascia of the arm will be exposed, through which the fibers of the coracobrachial muscle will be visible. The fascia is divided upon the grooved director and the lower (inner) lip of the wound in skin and fascia is retracted with tenacula. There now comes into view the median nerve, embedded in loose cellular tissue, and this is drawn upward (outward) with a simple blunt hook. The artery is now exposed and





can readily be isolated and ligated (Plate 1). Care must be taken that the nerve alone is grasped and drawn out of the way, as otherwise the artery, which lies directly behind it, may also be displaced and removed from the field of view.

After division of the fascia of the coracobrachial muscle the greater internal cutaneous nerve sometimes presents itself. This small nerve can scarcely be confounded with the median nerve, which comes into view after further retraction of the lower (inner) margin of the wound.

The artery is accompanied by one or several veins, sometimes by a whole plexus of veins.

Ligation of the Brachial Artery.—The continuation of the axillary artery from the surgical neck of the humerus to the point of arterial division at the flexure of the elbow is known as the *brachial artery*. The vessel lies in the internal bicipital sulcus, and it is often accompanied by a network of veins. The median nerve lies over the upper half of the artery, which it conceals, while in their further course the nerve lies upon the ulnar side of the vessel. The basilic vein, which likewise lies in the internal bicipital sulcus, is separated from the group of large vessels and nerves by the fascia. The sheath of the vessel consists of loose and reticulated cellular tissue.

The patient occupies the same position as in ligation of the axillary artery. The incision is made at about the middle of the arm, slightly over (external to) and parallel with the internal bicipital sulcus (Fig. 46). Skin and subcutaneous connective tissue are divided, and the fascia of the biceps muscle is opened in the same direction and throughout the same extent. The fibers of this muscle must be clearly exposed to view. The lower (inner) lip of the wound in the fascia is drawn downward (inward) with a tenaculum, and the median nerve is thus exposed. The nerve is lifted from its bed and drawn aside with a blunt hook, when the brachial artery, lying behind, is exposed, accompanied by veins. The artery is isolated by

means of two pairs of forceps for application of the ligature (Plate 1).

The rule to make the incision somewhat above (external to) the bicipital sulcus in order to reach the median nerve below is to be recommended on account of the difficulties encountered in exposing the artery by an atypical route through a mass of structures, including the greater internal cutaneous nerve, the median nerve, and the basilic vein, when the incision is made directly over the vessels and nerves. If the incision is made below (internal to) the bicipital sulcus, an inexperienced person may err by failing to recognize the exposed ulnar nerve and looking in vain for the artery behind it.

The relations between the median nerve and the brachial artery are variable within certain limits. In rare instances the artery lies in front of the nerve. In cases of high origin of the radial and ulnar arteries one of the vessels lies in front of and the other behind the nerve. The presence behind the median nerve of an artery disproportionately small, as compared with the rest of the body, is suggestive of such high division of the brachial artery.

Ligation of the Cubital Artery.¹—The continuation of the brachial artery in the flexure of the elbow is known as the *cubital artery*. The vessel lies in the internal cubital sulcus, and, covered by the aponeurosis of the biceps muscle, is embedded in the depression between the pronator radii teres and the biceps. The artery is in this situation accompanied by two symmetrically placed veins. The median nerve does not occupy the same intimate relation with the artery as it does in the arm, but it is displaced to the ulnar aspect of the artery. Separated from the artery by the bicipital fascia and situated subcutaneously is the cubital plexus of veins (median basilic, median cephalic), which communicates in the flexure of the elbow with the veins accompanying the artery.

The simplicity of the relations existing in the arm, in

¹ We usually speak of this operation as ligation of the brachial at the bend of the elbow.—ED.

consequence of the prominences formed by the biceps and

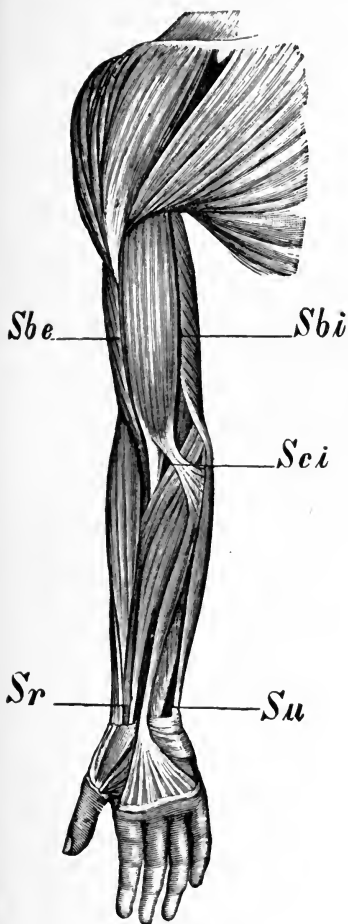


FIG. 47.—Arrangement of the muscles in the upper extremity: *Sbi*, internal bicipital sulcus; *Sbe*, external bicipital sulcus; *Sci*, internal cubital sulcus; *Sr*, radial sulcus; *Su*, ulnar sulcus.

the triceps and the presence of the internal and external bicipital sulci, is replaced at the flexure of the elbow-

Plate 2.—Exposure of the Cubital Artery (Right Arm).

L, aponeurosis of the biceps muscle; *A*, cubital artery accompanied by veins; *M*, median nerve; *U*, cubital veins.

Exposure of the Radial and Ulnar Arteries.

Ar, radial artery; *Au*, ulnar artery at the inner side of the tendon of the internal ulnar muscle (*U*).

joint by somewhat more complex conditions resulting from the presence of the two large groups of forearm muscles arising from the arm. The spindle-shaped belly of the biceps, gradually diminishing in size, is separated by a sulcus upon the right and the left respectively from the muscular prominences of the extensors and flexors of the forearm, which originate in this situation. There results thus a Y-shaped formation, of which the two arms, in some degree the continuations of the bicipital sulci of the arm, are designated the internal and external cubital sulci. The inner furrow of the flexure of the elbow is bounded by the biceps and the pronator radii teres, the outer by the biceps and the supinator longus. The internal cubital sulcus is covered by the aponeurosis of the biceps that spreads out into the fascia of the forearm (Fig. 47).

To ligate the cubital artery the forearm is extended at the elbow-joint and held in a position of maximum supination. Information as to the course and situation of the internal bicipital sulcus is sought through palpation. The incision is made in the continuation of the internal bicipital sulcus, and passes from within and above downward and outward, corresponding to the direction of the internal cubital sulcus (Fig. 48). After division of the skin consideration should be given to the network of veins at the flexure of the elbow. When possible, the way is cleared by retraction of the veins with blunt hooks. The shining aponeurosis of the biceps muscle now appears in the wound, and it is divided upon the grooved director in the direction of the cutaneous wound. The artery lies immediately beneath the aponeurosis, accompanied by two





veins, in a bed of loose connective tissue. The median nerve lies to the ulnar side of the artery (Plate 2).

In case of high division of the brachial artery one of the two branches may lie upon the bicipital fascia. This



FIG. 48.—Incisions for exposure of the cubital, radial, and ulnar arteries.

possibility is to be thought of when bleeding from the veins at the flexor of the elbow is to be undertaken, or when one of the median veins in this situation is to be exposed and opened for infusion of saline solution or for transfusion of blood.

In the practice of *phlebotomy* a cloth or bandage is bound circularly about the middle of the arm in such a manner that the return of blood through the veins from the forearm is prevented without obliteration of the radial pulse. With the forearm extended, a sharp-pointed knife is introduced obliquely into one of the tensely distended median veins (Fig. 49), so that the blood spurts from the wound in a stream. When the

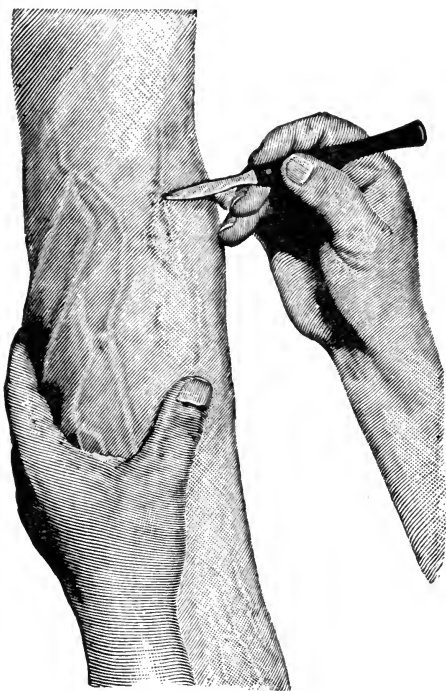


FIG. 49.—Phlebotomy at the flexure of the elbow: opening of the median basilic vein by puncture with a sharp-pointed knife.

desired amount of blood has escaped the compress is released, and the small wound is covered with a dressing and a bandage.

Transfusion of blood or *venous infusion* of saline solution also is practised through the median basilic vein. Through an incision analogous to that made for ligation of the cubital artery the vein, lying subcutaneously, is exposed for a distance of several centimeters and isolated by blunt dissection. The vessel is grasped with a pair of anatomic forceps and snipped with the scissors, without being totally divided. The vein is

now closed by ligature on the peripheral side of the incision. Through the opening thus made the cannula is introduced into the vein in a centripetal direction and fixed. To make the infusion a sterilized rubber tube armed with a funnel is most advantageously employed, attached to the cannula. From a half-liter to a liter and a half of fluid are permitted slowly to flow into the vein under a low degree of pressure. For purposes of infusion sterilized physiologic (0.6 per cent.) solution of sodium chlorid or defibrinated human blood may be employed. After the infusion has been completed the vein is ligated upon the central side of the opening and the small wound is closed by suture.

Ligation of the Radial and Ulnar Arteries.—The muscles upon the palmar aspect of the forearm are divisible into three groups. The main mass is formed by the flexors of the fingers, which arise by a common head from the inner aspect of the lower extremity of the humerus. The forearm is bounded upon the ulnar side by the flexor carpi ulnaris, upon the radial side by the supinator longus. Between the tendons of these muscles and the mass of the flexors of the fingers there is thus formed in the lower third of the forearm upon either side a longitudinal furrow or depression which is used as a guide in finding the radial and the ulnar artery respectively (Fig. 48).

The *radial artery* corresponds in its course with the direction of the radius. In the upper third of the forearm the artery lies in close relation with the supinator longus muscle and is deeply situated. In the lower third it lies more superficially in the sulcus between the tendons of the flexors and that of the supinator longus. Just above the wrist-joint the artery, with its accompanying two veins, lies upon the lower extremity of the radius, covered only by skin and the thin fascia.

The *ulnar artery*, after its origin from the brachial, crosses the common head of the flexors, among which it pursues its course, until it reaches the tendon of the flexor carpi ulnaris, along the inner side of which it reaches the wrist-joint.

The typical situation for the ligation of both arteries is just above the wrist-joint. The forearm is placed in a position of maximum supination, with the hand in slight

dorsal flexion. To expose the radial artery an incision is made just above the wrist-joint, corresponding to the depression between the tendon of the supinator longus and

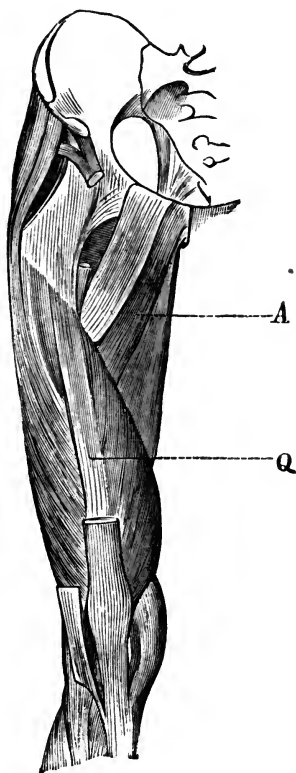


FIG. 50.—Arrangement of the muscles of the thigh : *A*, adductor group ; *Q*, quadriceps femoris.

the tendons of the flexors (Fig. 48). After division of the skin, the artery, covered by delicate translucent fascia, is seen, situated between two veins. After division of the fascia the artery can be isolated and ligated (Plate 2).

The ulnar artery is reached through a short incision in the ulnar sulcus just above the wrist-joint, somewhat to the radial side of the readily palpable tendon of the flexor carpi ulnaris. The radial margin of this tendon is exposed and drawn to one side with a tenaculum. The deep

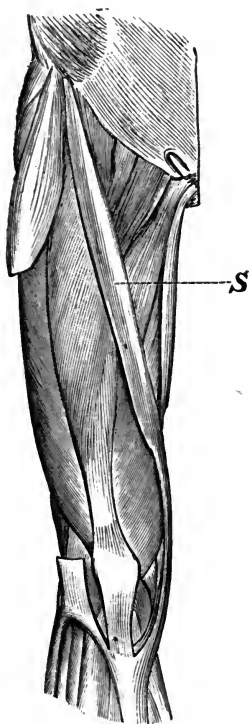


FIG. 51.—Course of the sartorius muscle (S).

layer of fascia enclosing the flexors is brought into view and divided upon a grooved director. The artery, accompanied by two veins, is now disclosed. In close relation with the artery upon its ulnar side lies the ulnar nerve.

Plate 3.—Exposure of the Femoral Artery.

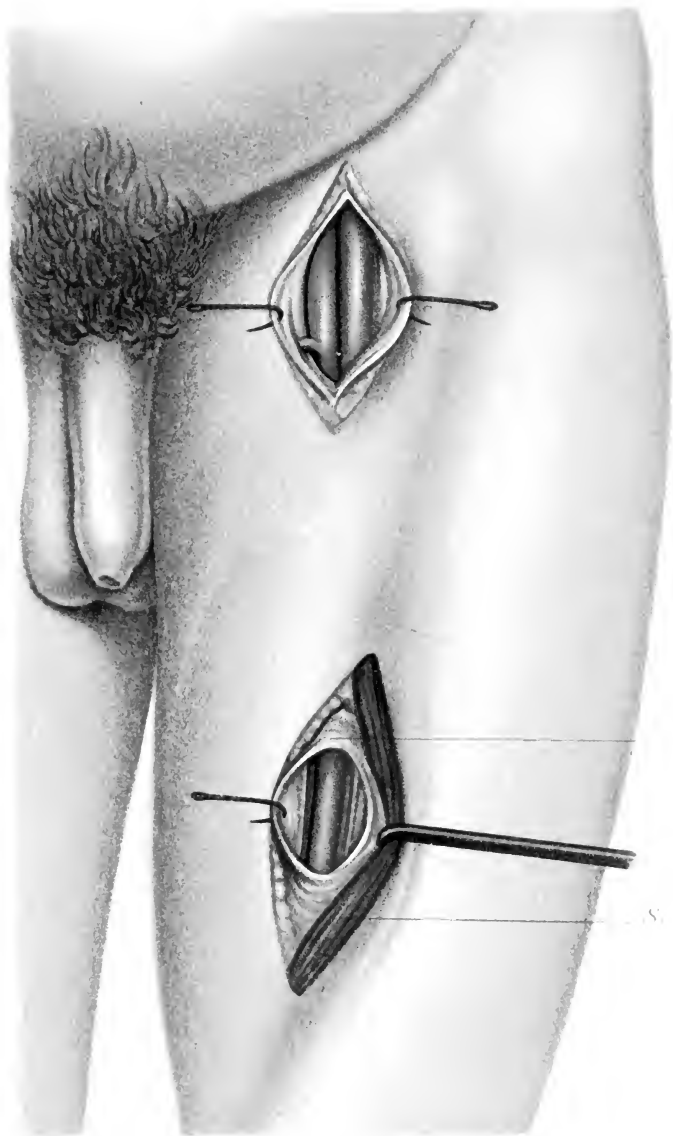
Below Poupart's ligament, in the opened sheath of the vessels, are to be seen, upon the median side, the femoral vein, and upon its outer side, the femoral artery. In the middle of the thigh the sartorius muscle (*S*) is drawn outward, the deep layer of the fascia (*f*) being divided, and the artery is exposed, with the vein behind it.

The radial artery, in its further course, is conveniently accessible upon the dorsum of the hand between the tendon of the flexor longus pollicis and that of the extensor brevis pollicis, in the so-called *tabatière*.

In the palm of the hand the superficial palmar arch of the ulnar artery can be exposed after division of the tough palmar aponeurosis. The cutaneous incision in the palm passes from the middle of the root of the hand toward the base of the little finger.

Ligations in the Lower Extremity.—The muscles of the thigh are so grouped that between the extensors and the flexors, which are arranged symmetrically upon the anterior and posterior aspects of the femur, on the median side one group of muscles passes from the pelvis to the inner aspect of the femur, separating the quadriceps from the flexors. The depression thus formed between the extensors and the adductors (Fig. 50) serves as a pathway for the vessels passing over the margin of the pelvis, and corresponds in its direction with the course of the vessels. The sartorius muscle bridges over this gutter (Fig. 51) and constitutes thus an important landmark in locating the vessels.

The *femoral artery*, the continuation of the external iliac, emerges from the pelvis under Poupart's ligament through the opening for the vessels at a point midway between the symphysis pubis and the anterior superior iliac spine into the subinguinal fossa. It passes under Poupart's ligament at a point corresponding to the middle of a line drawn from the symphysis pubis to the anterior superior iliac spine. The femoral vein lies to the median side of the artery, and occupies the same canal in



f.

s.



entering the pelvis from the thigh. The artery follows the direction of the muscular groove already mentioned. From the middle third of the thigh onward the sartorius muscle lies in front of the artery, which in this situation is covered by the tense fibers of the deep layer of the fascia lata. In order to gain entrance to the popliteal space the artery passes through the so-called *adductor canal*. This canal (Hunter's) is situated between the *adductor magnus* and the *vastus internus*, and is bridged over by fibrous bands stretched between the two muscles. The artery, with its accompanying veins, traverses this canal, then passes through an opening in the adductor tendon, and thus comes to lie in the popliteal space upon the posterior surface of the femur.

The *femoral vein* lies in the subinguinal fossa to the *median side of the artery*. In the further course of the vessels they cross in such a way that the vein comes to lie behind the artery. This relation is attained in the middle of the thigh, and the vessels thus pass through Hunter's canal. In approaching the vessels from the posterior aspect of the popliteal space the vein will consequently come first into view, while in front of it, in intimate relation, lies the artery.

The femoral artery may be ligated :

- (1) In the subinguinal depression, directly below Poupart's ligament.
- (2) In its course behind the sartorius muscle, at the junction of the middle and upper thirds of the thigh.
- (3) In Hunter's canal.

I. Ligation of the Femoral Artery below Poupart's Ligament.—The incision through the skin is made parallel with the axis of the thigh from Poupart's ligament downward for a distance of from 5 to 8 cm. (2–3 in.). The upper extremity of the incision corresponds with a point midway between the symphysis pubis and the anterior superior iliac spine (Fig. 52, *a*). After division of the skin and the fatty connective tissue careful dissection is made downward in a vertical direction until the sheath of

Plate 4.—Exposure of the Femoral Artery in the Adductor Canal.

*V*_i, vastus internus; *S*, sartorius. The fibrous covering of Hunter's canal (*f, f.*) is divided, with exposure of the femoral artery and vein.

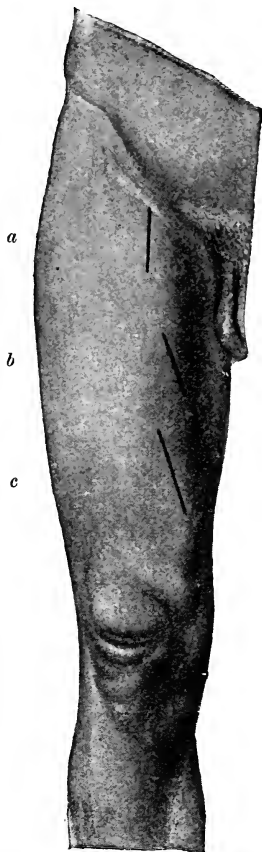
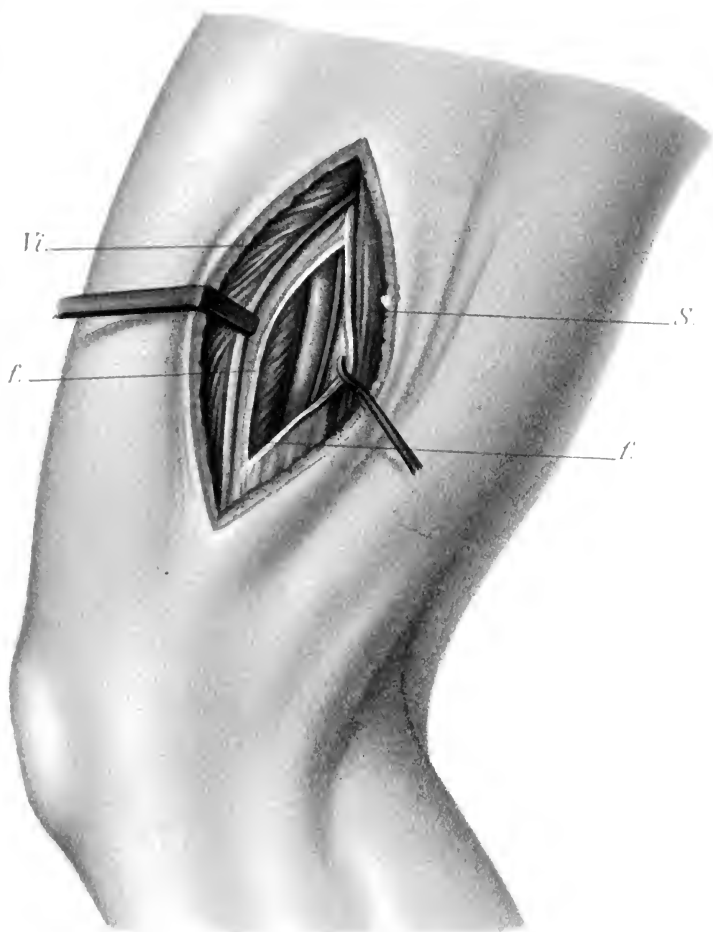


FIG. 52.—Cutaneous incisions for ligation of the femoral artery: *a*, below Poupart's ligament; *b*, below the sartorius muscle; *c*, in the adductor canal.





the vessels is recognized by its fibrous structure and whitish appearance. The sheath is divided upon a grooved director, and the artery is isolated for a short distance with two pairs of forceps and raised from its bed. The femoral vein can be brought into view upon the median side of the artery. The crural nerve lies some distance to the outer side of the vessels, covered by the deep layer of the fascia lata.

II. Ligation of the Femoral Artery at the Junction of the Middle and Upper Thirds of the Thigh.—By inward rotation of the thigh the depression following the course of the sartorius muscle, from above and without downward and inward, upon the inner aspect of the femur, can be brought into view. The incision through the skin is begun at the junction of the middle and upper thirds of the femur, and follows the line of this depression along the inner border of the sartorius muscle (Fig. 52, *b*). After the subcutaneous connective tissue has been passed, the delicate fascia of the thigh comes into view and should be divided in the direction of the cutaneous incision. If the incision be properly placed, the sartorius muscle comes into view after division of the fascia, being recognized by its muscular fibers running parallel with the cutaneous incision. If the fibers of the exposed muscle pass from within and above outward and downward, or the reverse, it may be known that the incision has been made too far inward or outward, and that the muscle disclosed is the adductor magnus or the vastus internus. The median border of the sartorius muscle is exposed by dissection with the knife, and the muscle is raised from its bed and drawn outward, when the deep layer of the fascia lata will be seen stretched tightly over the vessels. After division of the fascia upon the grooved director, the artery, which in this situation lies in front of the vein, is isolated by blunt dissection and ligated (Plate 3).

III. Ligation of the Femoral Artery in the Adductor Canal.—The extremity is flexed at the knee and the hip and slightly abducted and rotated outward at the hip-

Plate 5.—Exposure of the Popliteal Artery. Left Lower Extremity, Flexor Aspect.

S, semimembranosus; *B*, biceps femoris; *T*, triceps; *I*, branches of the sciatic nerve; *A*, popliteal artery; *V*, popliteal vein.

joint. The cutaneous incision is begun at the junction between the middle and lower thirds of the thigh, along

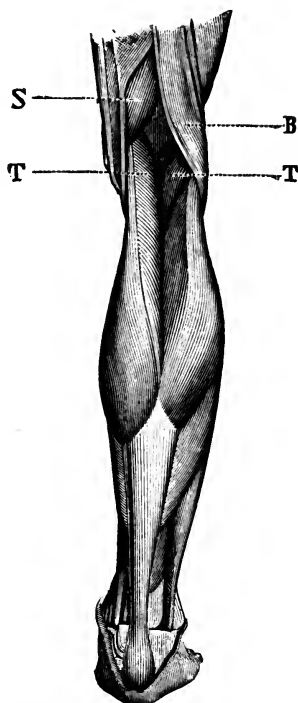
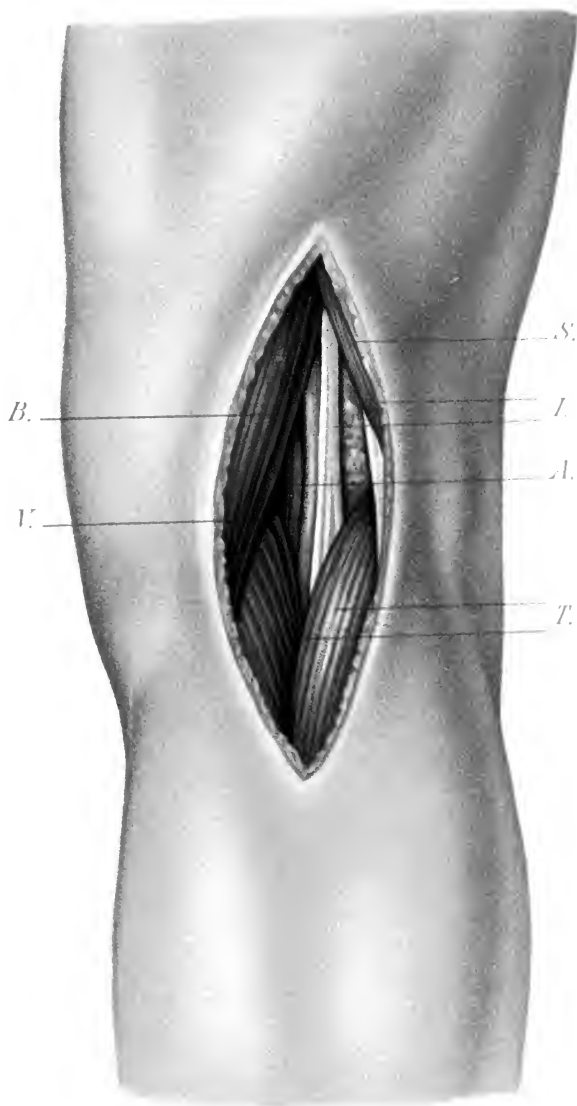
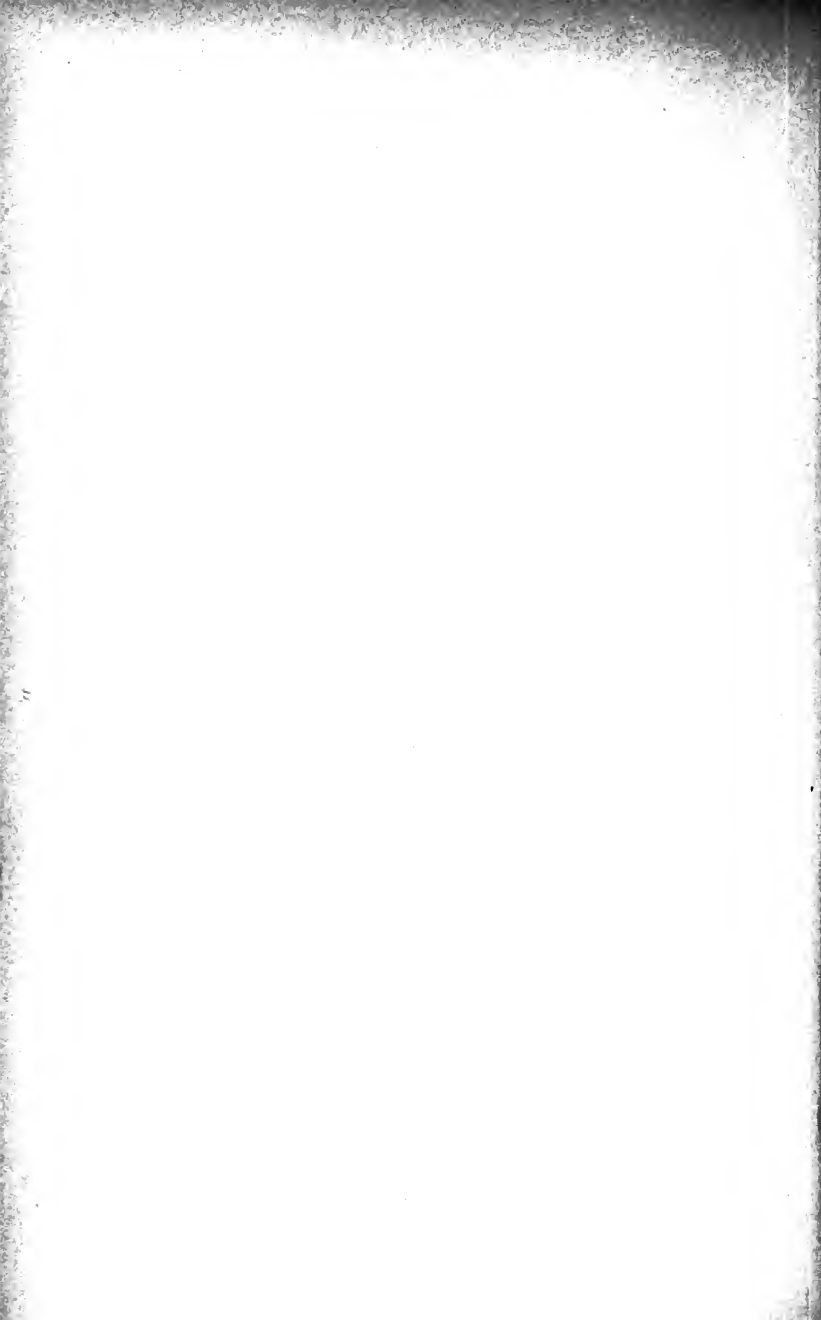


FIG. 53.—The muscles of the popliteal space and of the calf of the leg: *S*, semimembranosus; *B*, biceps femoris; *T*, *T*, heads of the gastrocnemius.

the lateral border of the sartorius muscle (Fig. 52, *c*). The dissection advances between the vastus internus and





the sartorius until the silvery, fibrous sheath stretched between the adductor magnus and the vastus internus comes clearly into view. The fibers of this sheath, which form the covering of the adductor canal, are divided, when the artery is disclosed most superficially. The vein lies behind the artery, to which it is intimately attached by connective tissue (Plate 4).

Ligation of the internal saphenous vein has been recommended by Trendelenburg in the treatment of varicose veins of the lower extremities. A cutaneous incision about 3 cm. (1 in.) long is made on the inner aspect of the thigh at the junction of its middle and upper thirds. A catgut ligature is thrown around the isolated vein and the extremity is elevated in order that the blood may make its exit. Two ligatures are applied to the vein and the vessel is divided between them. The small wound in the skin is closed by sutures.

Ligation of the Popliteal Artery.—The popliteal space is bounded above by the biceps femoris and the semi-membranosus muscles, and below by the two heads of the gastrocnemius (Fig. 53). The popliteal artery and vein pass deeply in the longitudinal axis of this lozenge-shaped space, the artery more deeply than the vein and almost in contact with the capsule of the knee-joint. The continuation of the sciatic nerve lies over the vessels and almost immediately beneath the superficial fascia.

For the ligation of the *popliteal artery* the patient is placed in the prone position, and a longitudinal incision is made in the middle line of the popliteal space (Fig. 54). After division of the skin and the fascia the tibial nerve, which is superficial, is exposed. This nerve serves as a guide to the vessels, which will be found by advancing more deeply into the fatty connective tissue of the popliteal space at the side of the nerve. The vein lies behind the artery, with which it is intimately connected by cellular tissue.

Another way of reaching the popliteal vessels consists in entering the popliteal space from the inner aspect of the lowermost extremity of the thigh behind the tendon of the adductors, between this and the tendons of the gracilis and the sartorius. The extremity is flexed at the knee-joint, abducted, and rotated outward at the hip-joint. The adductor tendon can be felt on the inner side above the inner condyle,

and behind it there is a slight depression in the skin. An incision is made in this situation in the long axis of the thigh, and after division of the fascia the adductor tendon can be separated by blunt dissection from the sartorius and gracilis muscles. The popliteal mass of fat exposed is entered from the side, and the sheath of the vessels is found upon the floor of the popliteal space.

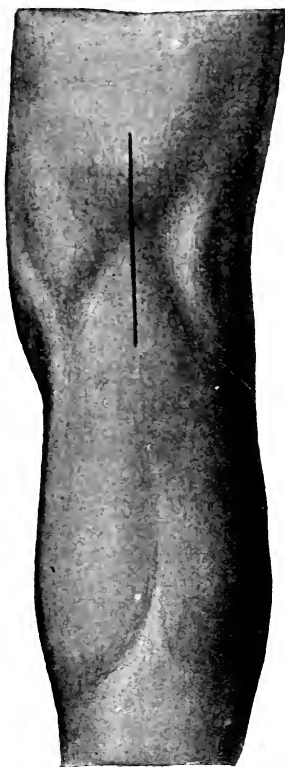


FIG. 54.—Cutaneous incision for ligation of the popliteal artery.

Ligation of the Anterior and Posterior Tibial Arteries.—The muscles of the leg are so arranged that the extensors lie upon the anterior surface of the interosseous ligament,

while upon the posterior surface lie the flexors. The latter are covered by the calf-muscles. The peronei muscles are grouped about the fibula. Upon the anterior aspect of the leg the vessels lie directly upon the interosseous ligament and pass among the muscles toward the dorsum of the foot. Upon the posterior aspect the vessels and the nerves pass in the interval between the calf-muscles and the flexors.

The popliteal artery divides at the lower border of the popliteus muscle into the tibioperoneal trunk and the anterior tibial artery. The posterior tibial artery and the peroneal artery, branches of the tibioperoneal trunk, pass downward between the superficial and deep layers of muscles upon the flexor aspect of the leg, separated from the calf-muscles by a layer of fascia.

The posterior tibial artery runs close to the tibia and comes to lie behind the internal malleolus, in which situation, corresponding to the origin of the abductor hallucis, it divides into the internal and external plantar arteries. The peroneal artery runs in the same plane along the fibula toward the external malleolus, where it terminates in several branches.

The anterior tibial artery penetrates the interosseous ligament from the flexor aspect of the leg and thus comes to lie upon the anterior surface of the ligament, beneath the muscles. In this situation the vessel runs along the outer border of the tibialis anticus muscle toward the foot (Fig. 55). Reaching the dorsum of the foot, the artery, here known as the *dorsalis pedis*, lies upon the outer side of the tendon of the *extensor proprius pollicis*. In the space between the metatarsal bone of the great toe and the second metatarsal bone the artery descends toward the sole of the foot, where it unites with the external plantar artery, one of the two terminal branches of the posterior tibial artery.

The anterior tibial artery is accompanied by the anterior tibial nerve, and the posterior tibial artery by the posterior tibial nerve.

Plate 6.

FIG. 1.—Exposure of the anterior tibial artery of the left leg. The fascia is opened, and the tibialis anticus muscle (*Ja*) is retracted toward the median line, and the extensor hallucis (*E.h.*) toward the outer side. In the interval between the two muscles the deep perineal nerve (*P.p.*) comes first into view and behind it the artery surrounded by veins.

FIG. 2.—Exposure of the posterior tibial artery behind the internal malleolus. The tortuous artery accompanied by two veins is visible beneath the divided fascia (*F*).

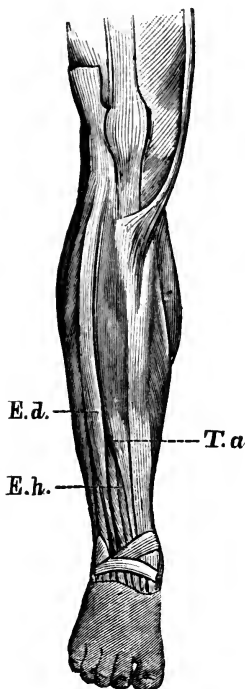
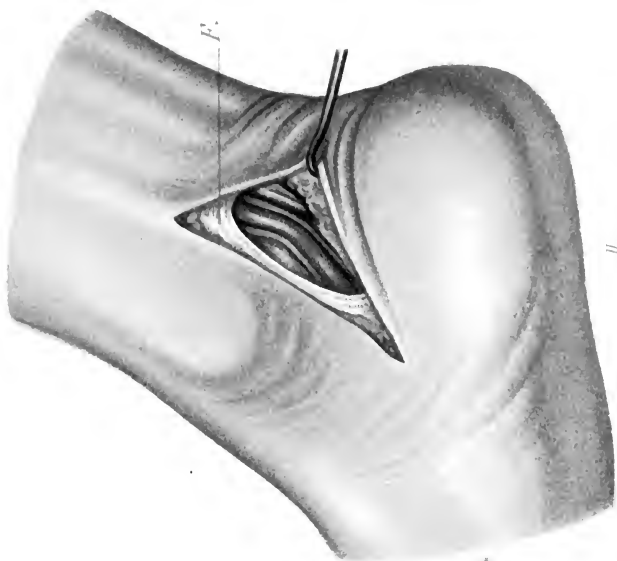
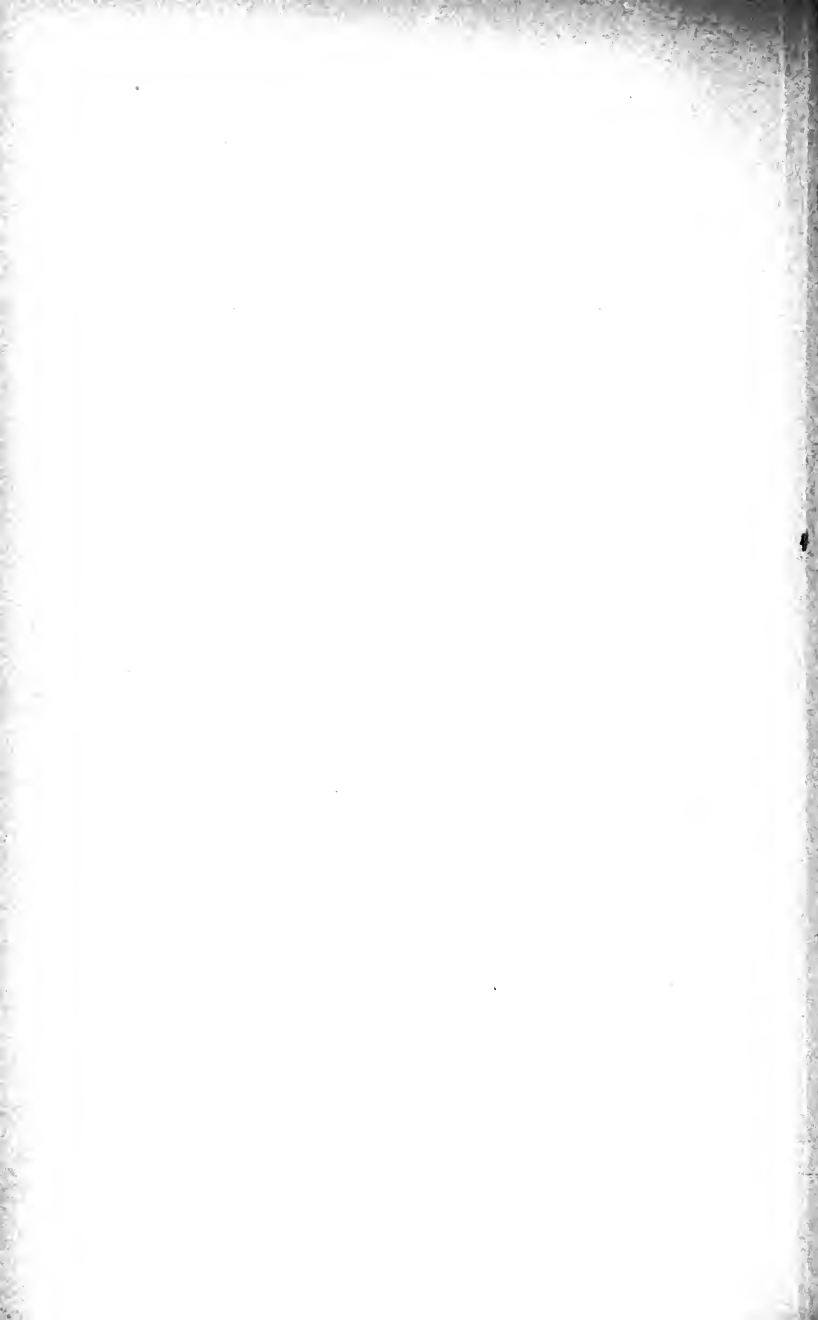


FIG. 55.—Arrangement of the muscles of the leg, anterior aspect: the artery lies upon the interosseous ligament and passes between the tibialis anticus muscle (*T.a.*) and the extensor communis digitorum (*E.d.*), or the extensor hallucis (*E.h.*).

The anterior tibial artery is ligated typically in its





course at a point corresponding to the junction of the middle and lower thirds of the leg, and as the *dorsalis pedis* upon the dorsum of the foot. The posterior tibial artery is exposed for ligation in its course upon the leg and behind the internal malleolus.

In ligating the *anterior tibial artery* an incision is made upon the anterior aspect of the leg in a situation corresponding with the junction of its middle and lower thirds, a finger's breadth external to the crest of the tibia (Fig. 56, *a*). After division of the tense and tough fascia in the line of the cutaneous incision, the dissection is proceeded with from the outer side of the tendon of the *tibialis anticus* muscle between this and the adjacent *extensor proprius pollicis* down to the *interosseous ligament*. Before the vessels are reached the *anterior tibial nerve* comes into view. Behind this lies the artery, surrounded by a network of veins (Plate 6, Fig. 1). To facilitate isolation of the vessel it is well to separate the *tibialis anticus* and the *extensor hallucis* muscles

vigorously with *tenacula*. In order to reach the artery readily it is important to follow accurately the interval between the muscles, as otherwise access to the vessels will be attended with difficulty. Entrance is secured from the outer border of the *tibialis posticus* muscle.

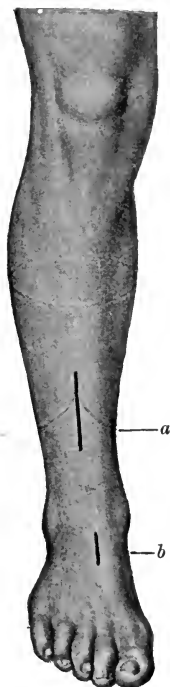


FIG. 56.—Cutaneous incisions for ligation of the anterior tibial artery (*a*) and the *dorsalis pedis* artery (*b*).

Plate 7.—Exposure of the Posterior Tibial Artery in the Left Leg.

The attachment of the soleus (*S.*) has been separated from the tibia. The muscles of the calf have been retracted by a tenaculum. The artery (*A.t.p.*), accompanied by a vein and covered by fascia, is seen upon the group of flexors to the outer side of the posterior tibial nerve (*N.t.p.*).

To expose the *posterior tibial artery* in its course along the leg, a longitudinal incision is made in the middle



FIG. 57.—Incisions for ligating the posterior tibial artery in the leg (*a*) and behind the internal malleolus (*b*).

third of the leg, a finger's breadth internal to the crest of the tibia (Fig. 57, *a*). After division of the skin and the fascia the fibers of the soleus muscle are freed from their attachment to the bone, and the interval between



the superficial and the deep group of calf-muscles occupied by loose connective tissue comes into view. If the muscles of the calf in the extent of the wound are raised from their bed with a blunt hook, the posterior tibial artery, accompanied by the nerve of the same name and several veins, will be found beneath the layer of fascia covering the deep group of muscles between the tibialis posticus and the flexor hallucis longus muscle (Plate 7).

In the ligation of the posterior tibial artery behind the internal malleolus the foot is rotated outward in maximum degree, and a curved incision encircling the malleolus is made at a point midway between the extremity of the internal malleolus and the median border of the tendo Achillis (Fig. 57, *b*). If the fibrous fascia is exposed, the artery comes into view, accompanied by two veins. After division of the fascia the artery can be isolated by blunt dissection. If the procedure be properly carried out, the muscular sheath of the tibialis posticus, the flexor hallucis longus, and the flexor digitorum is not opened. The posterior tibial nerve lies to the outside of the vessels (Plate 6, Fig. 2).

The *dorsalis pedis artery* is ligated upon the dorsum of the foot in front of the ankle-joint, the foot being held in strong plantar flexion. The tendon of the extensor proprius pollicis is thus made palpable, and an incision is made to its outer side and parallel with it. The fascia is now divided, and, in close relation with the bone, the artery, accompanied by two veins, is found to the outer side of the tendon of the extensor communis digitorum.

II. Amputations and Enucleations.

The surgical removal of an extremity or portion of an extremity is designated an *amputation* when the separation is made in the continuity of the bone, and an *enucleation* or *exarticulation* if the separation is made at an articulation.¹ The soft parts are variously divided in order that they may most advantageously cover the sawn bone or the articular extremity.

Indications.—(1) *Developmental anomalies*, supernumerary fingers, or acquired incorrigible deformities (contractures, atrophic extremities).

(2) *Injuries*, such as rending or crushing of the extremities, destruction of the skin over a large area; in general, when restoration of the function of the part seems to be precluded by the degree and the character of the injury.

(3) *Caries of joints* in adults, when conservative operations are no longer possible, or when the articular disease is superadded to pre-existing tuberculosis of the lungs or of other organs.

(4) *Infections*, phlegmonous inflammations of the tissues, gangrenous destruction of joints, osteomyelitis with epiphyseal separation and suppuration of joints, always when the morbid process cannot be localized.

(5) *Neoplasms*, malignant disease of bones and soft parts; rarely benign growths also, such as enchondromata of the fingers, furnish an indication for amputation or enucleation.

(6) *Gangrene* of the extremities.

(7) Incurable circumferential *leg-ulcers* and elephantiasis.

(8) Incurable *pseudarthroses*.

Reamputation is indicated in the presence of—

(1) *Neuralgia of the stump*, due to the presence of neuromata;

(2) *Conical amputation-stumps*.

¹ Also called a disarticulation.—ED.

FIG. 58.—Amputation of the leg, I.: Circular division of the skin; first step.



In the **performance of amputation** the patient is so placed that the member to be amputated is conveniently accessible. The upper extremities are raised to a horizontal position and there maintained by assistants. In removal of portions of the lower extremities the member, which is held horizontally, extends beyond the edge of the table. An assistant grasps the extremity at its peripheral end, and another assistant fixes it on the central side of the point selected for division.

Temporary control of hemorrhage is effected during the operation either by means of digital compression of the artery or by surrounding the extremity with the elastic tube (hemostasis) of Esmarch.

Digital compression is available only when the artery can be compressed against a firm base, as a bone. Thus, the femoral artery is compressed against the horizontal ramus of the pubic bone at the point where the vessel passes under Poupart's ligament; the subclavian artery is compressed in the supraclavicular fossa against the first rib.

In controlling hemorrhage by means of the *elastic bandage* or tube of Esmarch the extremity is held vertically for a short time, in order that gravity may empty it of blood, and is then surrounded by an elastic bandage or an elastic tube above the point of proposed operation.

Position of the Operator.—If the operator be right-handed, he takes such a position that the member to be amputated is upon his right. In amputations of the right upper extremity the member is abducted and raised to a horizontal position. The operator stands upon the outer side, with his face directed toward the feet of the patient. In amputations of the left upper extremity the operator stands between the trunk of the patient and the abducted arm, with his face directed toward the patient's head. In amputations of the right lower extremity the operator stands upon the outer side, and in operating upon the left side between the abducted lower extremities of the patient. The operator stands with his right foot slightly pushed

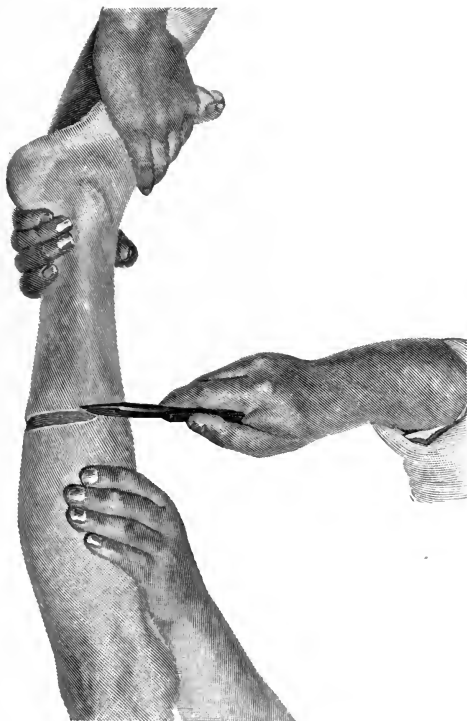


FIG. 59.—Amputation of the leg, II.: Circular division of the skin; second step.

forward and supports himself upon his left while making the incisions.

Steps of the Operation.—The operation includes the following four steps:

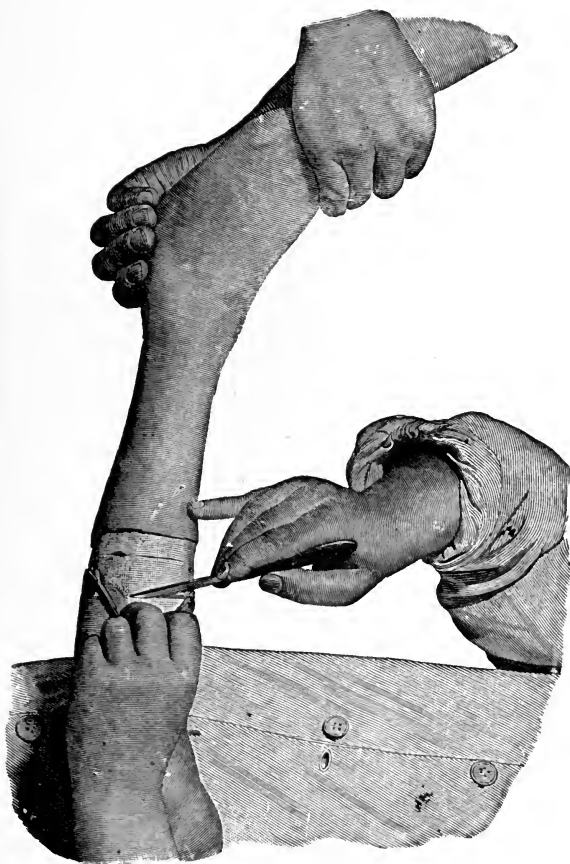
- (1) Division of the skin and the muscles ;
 - (2) Removal of the part, sawing through the bone ;
 - (3) Control of hemorrhage by ligation of the vessels ;
- and
- (4) Closure of the wound.

The *division of the soft parts* is so effected that after removal of the amputated part approximation of the wound by sutures is possible, the stump is adequately covered by the soft parts, and the cicatrix, especially following amputations of the lower extremity, is favorably situated. The soft parts are divided more or less transversely to the long axis of the member (*circular incision*), or *flaps* are formed from the soft tissues, which, after completion of the amputation, may be brought together and united. An intermediate mode of procedure between the two is known as racket or oval incision.

Circular Incision.—In accordance as the soft parts are to be divided transversely or obliquely to the long axis of the part to be amputated, a distinction is made between the *transverse* and the *oblique* circular incision. The division of the soft tissues down to the bone may be effected by a single incision, or the skin and the muscles may be divided at different layers by two incisions. The first method, which has been attributed to Celsus, has only a limited field of application. The second (J. L. Petit, Cheselden) was originally practised in such a way that the skin was first divided in a circular manner. The muscles were then divided at a more proximal level by a second incision, while retraction was practised. This form of incision in two steps is thus but a modification of the procedure of Celsus.

A better purpose is subserved in dividing the tissues by two cuts by first incising the skin circularly at some distance to the distal side of the point where the bone is

FIG. 60.—Amputation of the leg, III.: Dissection of the cuff.



to be sawed. To this end the knife is applied upon its heel with its point directed toward the operator, and is carried around the lower circumference of the member (Fig. 58). The knife is now applied with its heel at the beginning of the incision already made, and its point directed from the operator, and is carried around the upper circumference of the member in an opposite direction (Fig. 59). There thus results a circular cutaneous incision formed of two opposed semicircular ones. When the skin throughout the entire circumference has been uniformly divided down to the muscular fascia, it is throughout the whole extent of the circular incision dissected from the subjacent tissues in a proximal direction, so that there results a hollow cylinder or cuff constituted of skin and subcutaneous connective and fatty tissue. In the dissection of this cuff the operator grasps the margin of the wound from above with thumb and index-finger at a point in the circular incision most remote from him, and proceeds to separate it from the subjacent tissues. The fibers uniting the skin and the fascia are divided by strokes of the knife held vertically to the underlying structures (Fig. 60). The adjacent skin is now grasped and separated from the subjacent tissues in the same manner. The operator in this way gradually encircles the entire circumference of the extremity. When the starting-point has been reached, the process of detachment is renewed, and this is repeated until a cuff of sufficient size has been obtained and can be turned on itself.

It is important that the line at which the cuff is folded over should occupy a plane at right angles to the longitudinal axis of the member. The size of the cuff will be governed by the diameter of the member to be amputated. In general the cutaneous incision should be made upon the distal aspect of the plane of amputation at a distance equalling about two-thirds of the diameter of the extremity at the level of this plane.

The muscles are divided with long strokes of the am-

FIG. 61.—Amputation of the leg, IV.: Division of the muscles; first step in dividing the calf-muscles.

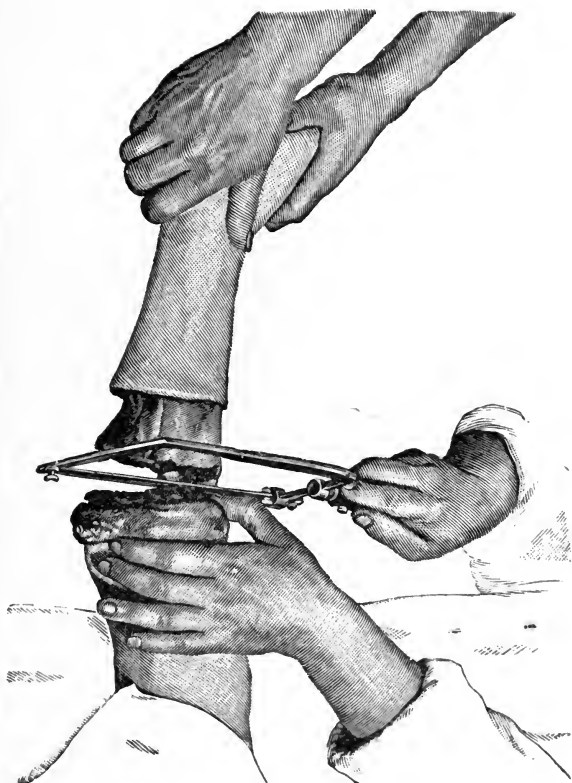


putation-knife at the level where the cuff of skin has been folded over in such a way that the cut surfaces of the muscles form an even plane. In the division of the muscles the knife is applied in the manner indicated in Fig. 61. Experience will teach the proper degree of pressure and of traction to be exercised. The knife is applied upon its heel and pressure is exerted upon the blade against the resisting mass of muscles, the operator at the same time making traction toward himself. In this way the muscles at the lower circumference are divided with a single stroke, the knife being drawn from heel to toe in a horizontal plane toward the operator. Without changing the position of the knife the blade is pushed forward horizontally up to its heel, when, beginning with pressure on the blade, while the hand is raised, the remainder of the muscular tissue upon the lower portion of the circumference and upon that portion directed toward the operator is divided. Next, the muscles of the upper portion are divided. To this end the knife is applied from above with its heel in the beginning of the incision and its point directed from the operator, and the muscles of the upper circumference are cut through.

In amputations of the leg and the forearm the division of the structures between the two bones requires a special procedure. After the muscles have been divided circularly in the manner described, a small knife is introduced into the interosseous space, with its edge at right angles to the bones, when the muscles and the ligaments of the interosseous space are severed by typical strokes of the knife directed toward each bone. The details of this procedure are described at length under Amputations of the Leg.

Flap-incision.—In this method of operating, the soft parts are incised in the form of flaps, which are used to cover the stump. Flaps may be made in various shapes—*e. g.*, semicircular, tongue-shaped, with parallel margins and rounded corners, etc. They consist of skin or of skin and muscular tissue, or of skin and periosteum, and they

FIG. 62.—Amputation of the leg, V.: Sawing of the bones of the leg.



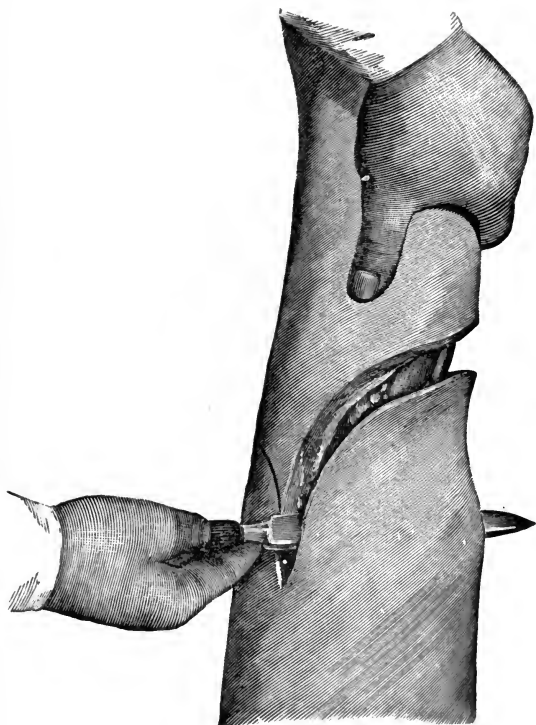
are accordingly designated tegumentary flaps, musculotegumentary flaps, tegumentary-periosteal flaps, etc. Portions of bone may also be included with the skin in flaps and be so adapted to the wound-surface of other bone as to contribute to the formation of a satisfactory stump. Flaps always contain a greater amount of tissue at their base than at their extremity. The stump may be covered with a single flap (Lowdham, Verduin) or with two flaps (Ravaton). Flaps may be made of equal or of unequal size, and in accordance with their situation they are designated anterior, lateral, or posterior.

The formation of flaps may be effected by incisions from without inward (Langenbeck), or the reverse by cutting from the base toward the periphery (transfixion), or, finally, by a combination of the circular incision with two longitudinal incisions at opposite points of the circumference, the base being enucleated from the periosteum through the lateral incisions, so that the structures of the flap retain their connection with the periosteum (Bruns).

In making incisions from without inward the shape of the flap is outlined with the knife, and the skin and fascia in this distribution are divided down to the muscular layer, when the flap retracts somewhat. From the line of retraction the muscular layer is divided with long strokes of the knife down to the bone, when the whole flap can be turned back. When a tegumentary flap is to be formed, the skin, after the outline of the flap has been made with the knife, is grasped with a pair of toothed forceps or a tenaculum, and raised, being progressively dissected from the subjacent structures.

In making flaps by transfixion smoother wound-surfaces can be obtained. One of two modes of procedure may be followed. The flap may be formed by direct transfixion, the knife being thrust transversely through the muscles close to the bone and cutting toward the skin. In the other mode of procedure the operator outlines the shape of the flap with the knife, at the same time dividing

FIG. 63.—Thigh : Formation of an anterior musculocutaneous flap by means of transfixion in two stages.

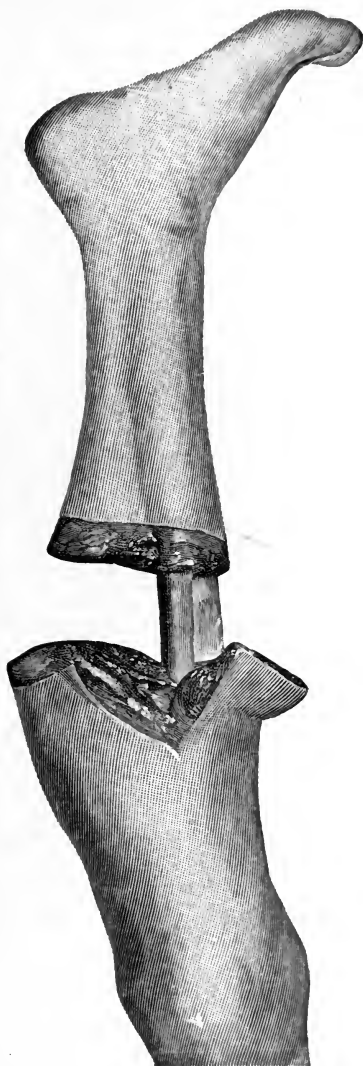


FLAP-FORMATION.



FIG. 64.—Flap-formation : flap formed of the muscles of the thigh, folded back.

FIG. 65.—The formation of two musculoperiosteal flaps in the leg by the method of Bruns.



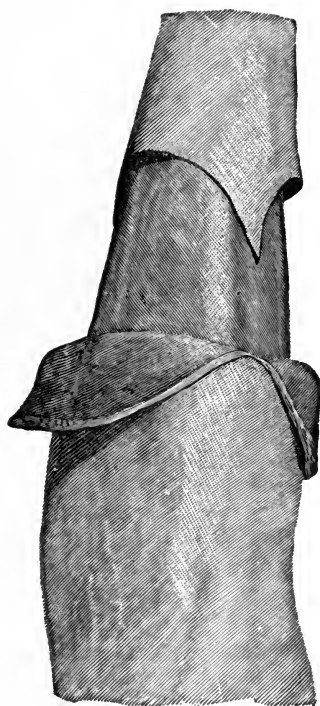
the fascia, so that the flap retracts somewhat. The knife is now introduced at the base of the flap in the manner already described, and is carried through the muscles to the end of the flap, where it makes its exit. By this means is attained the most advantageous distribution of the muscles in the flap, which at its periphery will consist only of skin and fat (Figs. 63 and 64).

When two flaps have been formed in one of the ways described, they are folded over and the muscular tissues yet attached to the bone are divided by a circular incision. In amputations of the leg or of the forearm the muscular tissue in the interosseous space should be divided according to established rules before the bones are sawed through.

In the *formation of flaps according to the method of Bruns* (Fig. 65) the soft parts are divided down to the bone by a circular incision. Then two longitudinal incisions are made at opposite points of the circumference of the circular incision, likewise extending down to the bones. Through these, with the aid of a raspator, the bone is freed of its periosteum, so that the entire structure of the flap, from the skin to the periosteum, retains its natural connections. Such flaps help to give the stump a good shape. They are unattended by secondary atrophy of the bone of the stump, as well as of the tissues of the flap, and this is of significance for the *usefulness of the stump*. The method of Bruns is, therefore, particularly applicable to amputation of the leg.

The oval incision results when the circular incision is joined at some point of its periphery by a longitudinal incision, which, like the circular incision, passes through the periosteum down to the bone. The apex of the oval is placed either upon the extensor aspect of the joint or upon one of its lateral aspects. From it pass two diverging incisions, which meet transversely at an opposite point of the periphery (method of Scoutetten). The form of the wound corresponds with that of a heart, the apex of the oval being the most central portion. The bone is removed

FIG. 66.—Leg: formation of two lateral cutaneous flaps.



at this level (Fig. 67). After union by suture the wound is linear. The oval incision is employed especially in enucleation of fingers and toes ; less commonly in enucleation of the shoulder-joint or the hip-joint.

Division of the Bone.—After complete division of the soft parts and incision of the periosteum the latter, in the area of the incision, is carefully detached from the bone for a short distance in a proximal direction with a raspator, in order that a sufficient surface may be exposed for the application of the saw and the periosteum be not



FIG. 67.—Oval incision for amputation of the index-finger at the metacarpophalangeal articulation.

crushed or in part torn from its attachments, and primary union be thereby prevented. In sawing through the bone care should be taken that the division is effected as far from the periphery as possible ; that the sawed surface is at right angles to the longitudinal axis of the bone ; and that the soft parts are protected from all injury. The muscles are drawn with tenacula out of reach of the saw, or the stump is wrapped in suitable retractors and thus protected.

In applying the saw the nail of the thumb of the left hand is placed vertically upon the denuded bone (Fig. 62), and the support thus afforded is used as a guide for the blade of the saw. At first the saw is manipulated without pressure. Only after a groove has been formed in the bone may the sawing be proceeded with more rapidly, with the application of a certain degree of pressure. An assistant, stationed at the periphery, holds the extremity in a position of extension and aims to keep the sawed surfaces apart in order that the blade of the instrument shall not become impacted. The irregular edges of the divided bone are trimmed by means of bone-forceps, and small projections are cut off.



FIG. 68.—Cutaneous suture after amputation of the leg through a circular incision.

Care of the Wound.—After removal of the amputated part has been effected, attention is directed to the permanent control of hemorrhage. The main arterial and venous trunks, recognizable by their position, are isolated in the stump with the aid of two pairs of dissecting-forceps, clamped in sliding-forceps, and ligated. In addition to the main arterial branches all vessels that can be seen running in the connective-tissue interstices of the muscles

are also ligated. The Esmarch bandage is now removed, and it may be found necessary to apply additional ligatures. Parenchymatous hemorrhage is controlled by compression.¹

The *care of the wound* has for its object accurate approximation of the wound-surfaces, with the avoidance of dead spaces, as well as exact approximation of the margins of the skin. The muscles may be separately united by

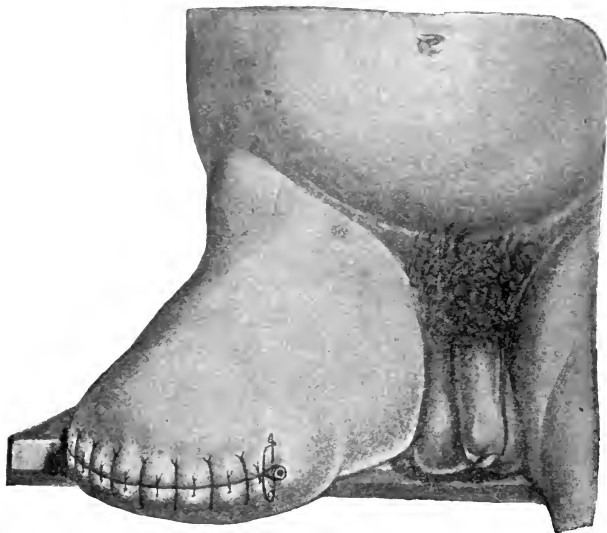


FIG. 69.—Cutaneous suture after flap-amputation of the thigh.

buried sutures, or coaptation of large areas of wound-surface is effected by means of gauze-pad sutures, while the skin is closed by superficial interrupted sutures, or by a continuous suture (Figs. 68 and 69).

If it has been possible to effect the amputation under complete aseptic conditions, the wound may be closed entirely by suture; otherwise drains should be brought to

¹ By the application of gauze pads wrung out in hot water.—ED.

the surface out of the depth of the wound. A like purpose may be subserved by the introduction of strips of sterile or antiseptic gauze or wicks.

In the performance of **exarticulation** the same general principles may be observed as in the performance of amputation. The operator stands at the periphery of the extremity, holding the part to be removed in the left hand, while the exarticulation is effected with the right. In the majority of cases the joint is opened from its extensor aspect. Flap-incisions and oval incisions are generally employed; less commonly circular incisions, with the formation of a cuff. The flaps are so formed that their base corresponds with the plane of the joint at which the separation is to be made. As a rule, flaps of unequal size are made. Upon that side of the joint on which the capsule is first opened the flap may be made by transfixion or by dissection from without inward. When the exarticulation is completed the soft parts upon the opposite side of the joint are divided from within outward. To this end the operator draws upon the extremity, grasped with the left hand and already freed at the articulation, in such a way that the bridge of skin still uniting the part with its central attachment is made perfectly smooth and free from folds. The knife is introduced into the wound, and divides the tense bridge of skin transversely. In cutting outward, care should be taken that the muscles and the skin, somewhat further toward the periphery, are first divided. The methods of performing exarticulation are in part so carried out that with the last incision of the knife, which passes from the wound and forms the flap, the main vessels are severed. During the process of cutting outward the artery may be closed by pressure with the finger in the wound. A method of exarticulation (Esmarch) often employed with large joints consists in circular division of the soft parts in the upper third of the extremity down to the bone after application of the Esmarch bandage. The bone also is divided at the level of the incision through the muscles. After ligation of

the vessels the constricting band is removed. A longitudinal incision is made through the soft parts down to the bone, from the joint to the primary wound, in such a way that large vessels and nerves are not divided. With the wound thus made held open by means of hooks, the joint is opened and the remainder of the bone removed with the utmost care. This combination of circular and longitudinal incisions constitutes a variety known as the racket-incision.

Amputations and Exarticulations in the Lower Extremity.—**Exarticulation of the Toes in the Interphalangeal or Metatarsophalangeal Joints.**—*Dorsal Opening of the Joint, with the Formation of a Plantar Tegumentary Flap by Incision from within Outward.*—The operator grasps with the index-finger and the thumb of the left hand the toe, flexed at the joint of separation, and the joint is opened by a transverse incision upon the extensor aspect, somewhat toward the distal aspect of the highest prominence of the joint. Then the lateral ligaments are completely severed until the joint is fully opened. Next a flap is formed from the plantar tissues by an incision from the wound outward. The length of the flap will be governed by the transverse extent of the exposed bone.

A large dorsal and a short plantar tegumentary flap may also be employed advantageously in the removal of toes; as well as *two lateral flaps of equal size*; or *a single lateral tegumentary flap*. In all cases the flaps are carefully outlined with the knife, separated from the subjacent structures, and the joint opened transversely from the extensor aspect. The flaps should always be so situated that their base corresponds with the joint-line at which the removal is to be effected.

In making an oval incision the knife is applied upon the dorsal aspect somewhat behind the line of the joint. The incision then runs parallel with the longitudinal axis of the digit in the middle line until it has passed the joint, on the distal side of which it deviates toward the

right, in order to run transversely upon the flexor aspect. From here it is continued around the bone until it reaches the dorsal aspect again, where it is completed by being carried to its point of origin. The joint is exposed upon its dorsal aspect by dissecting the two sides of the oval, and is opened transversely, when removal may be effected after division of the plantar tendons.

Amputation of a Toe through the Metatarsal Bone.—An oval incision is made, its apex corresponding with the point at which the metatarsal bone is to be sawed through. The incision passes longitudinally over the metatarsus beyond the metatarsophalangeal joint. It then passes around to the flexor aspect and back again on the opposite side, to return to its point of origin. The metatarsus is dissected free in the course of the longitudinal incision, and it is divided with the phalangeal saw or the chain-saw. The distal extremity is grasped and enucleated, and if this procedure has been carried out to the transverse incision in the flexor fold of the metatarsophalangeal joint, the separation will have been completed.

Amputation of all the Toes through the Metatarsus.—A large semicircular plantar and a short dorsal cutaneous flap are made. The operator stands at the periphery of the extremity, with the foot held in maximum dorsal flexion, and a plantar flap is cut and separated from the metatarsal bones. The dorsal tegumentary flap is then outlined and likewise dissected free. The metatarsal bones are surrounded totally by a circular incision, the muscles in the interosseous spaces divided, the periosteum of each bone individually pushed back at the place at which it is to be sawed through, and the saw finally applied from the dorsum of the foot to all the bones simultaneously (Fig. 70).

The plantar flap may also be formed by cutting outward from the wound after the bones have been sawed through. The dorsalis pedis artery and the digital arteries will require ligation.

Exarticulation of the Great Toe, together with the Meta-

tarsal Bone.—An oval incision is made with a prolonged apex. The dorsal incision begins on the extensor aspect over the tarsometatarsal joint, and passes in the longitudinal axis of the metatarsus to the lower end of this bone, where it deviates to one side, then surrounds the entire

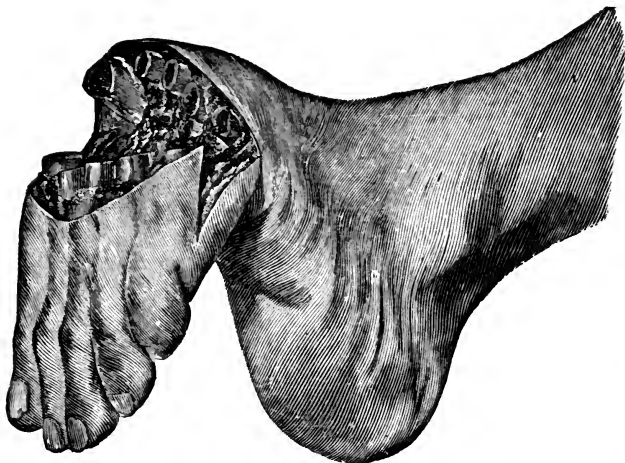


FIG. 70.—Amputation of the toes through the metatarsus: plantar musculo-tegumentary flap.

base of the toe, and thus again reaches the dorsal aspect of the toe, joining the original longitudinal incision. The incision at all points is made down to the bone. Hooks are introduced on either side of the longitudinal incision, and the muscles are separated from the metatarsus. While the toe is raised the metatarsal bone can also be freed from the muscles upon its under surface, when the joint between the internal cuneiform bone and the base of the metatarsus can be opened on its dorsal aspect. Linear closure of the wound is finally effected.

Exarticulation of the Little Toe, together with the Metatarsal Bone.—A lateral flap is formed according to the method of Walther. The operator grasps the abducted

little toe and applies the blade of the knife vertically in the interdigital fold between this and the adjacent toe, when the soft parts of the interspace are divided, by sawing movements of the knife held close to the metatarsal bone of the little toe, to the tarsus. From this point, with abduction of the toe and the metatarsus, entrance is gained into the joint between the fifth metatarsus and the cuboid bone, when the toe is bent outward at the joint at a right angle or more. The operator incises the tissues around the tuberosity of the metatarsal bone close to the bone, and with sawing-movements detaches the soft parts from the outer side of the metatarsal bone until a flap has been secured of sufficient extent to cover the wound made. The flap is cut transversely from the wound outward.

The little toe may also be exarticulated at the tarso-metatarsal joint by means of an oval incision, the apex of which is made upon the dorsum of the foot, as in removal of the great toe. The apex of the oval, as well as the longitudinal incision, may also be placed advantageously upon the lateral border of the foot.

Removal of the Foot at the Tarsometatarsal Joint. Lisfranc's Operation.—It is important to determine the situation of the ends of the line of the tarsometatarsal joints upon the surface of the inner and outer borders of the foot. The outer extremity corresponds with a point just behind the readily palpable tuberosity of the fifth metatarsal bone, while the inner extremity is about two fingers' breadth in advance of the prominent tuberosity of the scaphoid bone. The line of the tarsometatarsal joints is not a directly transverse line between the two points named, but it pursues a complex course. From the fifth metatarsal bone it passes forward at an angle of 45° ; then it passes inward along the base of the fourth metatarsal bone. The next joint, between the external cuneiform and the base of the metatarsal bone of the middle toe, is directly transverse, but projects somewhat forward. The articulation between the metatarsal bone of the second toe and the middle cuneiform bone is also trans-

Plate 8.—Lisfranc's Articular Line.

Cu, Cuboid bone; *E*, *M*, *K*, cuneiform ossicles; *I*, metatarsus of the great toe.

verse, somewhat behind that of the third metatarsal bone and in the line of that between the fourth metatarsal and the cuboid bone. The internal cuneiform bone projects forward (Plate 8, Fig. 71).

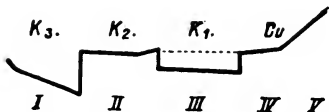
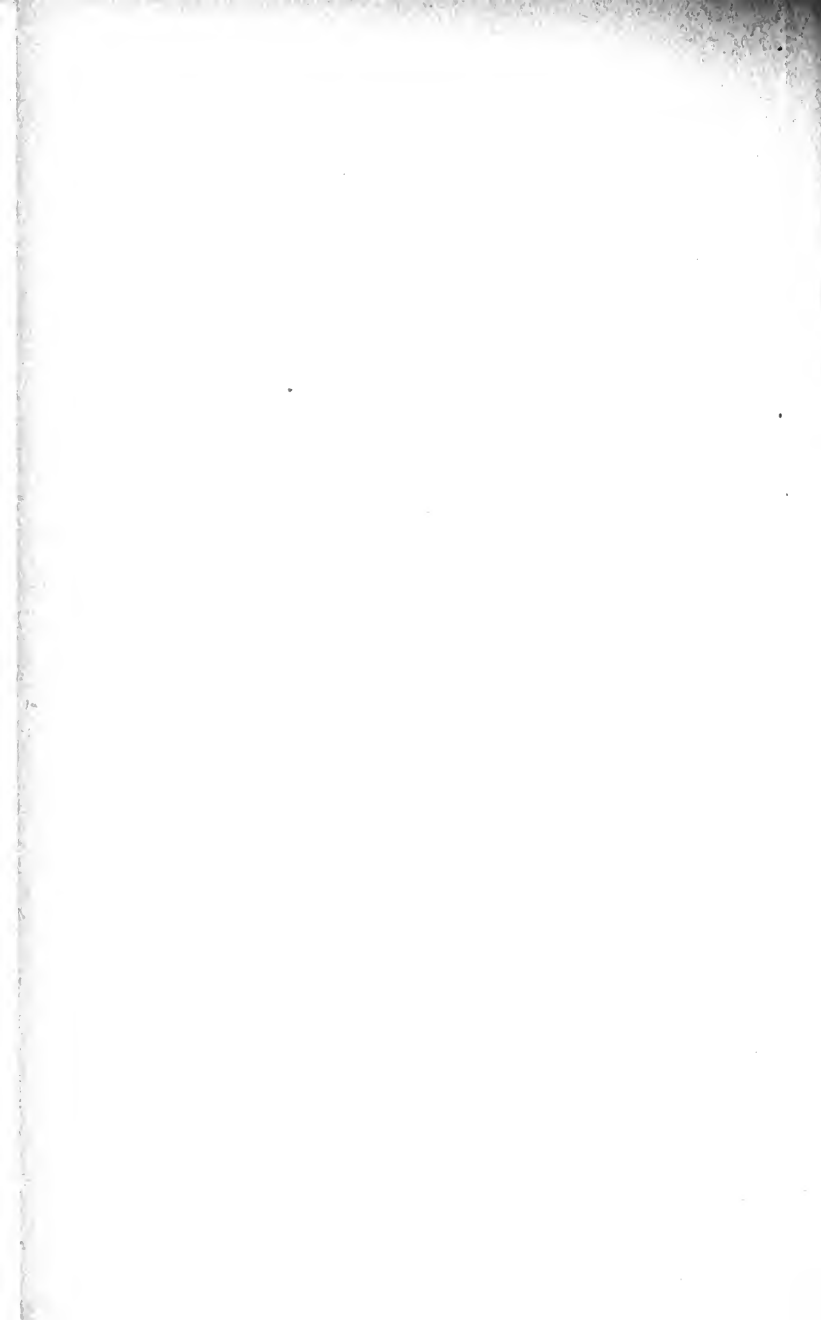


FIG. 71.—Course of Lisfranc's articular line (after van Walsem): *Cu*, cuboid bone; *K*₁, *K*₂, *K*₃, external, middle, and internal cuneiform bones. *I*, *II*, *III*, *IV*, *V*, articular surfaces of the corresponding metatarsal bones. *I*, metatarsal bone of the great toe.

Steps of the Operation.—The principle of the operation consists in dorsal opening of the joint and the formation of a musculotegumentary flap from the sole by an incision from within the wound outward. The operator stands at the periphery of the foot to be amputated, which he grasps from the sole, and with thumb and middle finger he marks the extremities of Lisfranc's articular line. Then an incision through skin and fascia is made on either margin of the foot down to the muscles between these two points—a thumb's breadth in advance of the scaphoid tuberosity on the inner side and just behind the tuberosity of the fifth metatarsal bone on the outer side—and carried forward beyond the heads of the metatarsal bones. A horizontal incision convex anteriorly is carried over the dorsum of the foot and unites the posterior extremities of the lateral incisions. After division of the skin and the subcutaneous connective tissue the dorsal flap is somewhat retracted. At the point of retraction the tendons and muscles of the dorsum of the foot are divided accurately in the direction of the cutaneous incision. There are thus exposed upon the dorsum of the foot the bones and the



ligaments of the joints throughout a small extent. The delicate dorsal capsules of the joints are now slit open, with the foot held in slight plantar flexion. The opening of the joints is always begun at the external border, at the articulation between the fifth metatarsal bone and the lateral facet of the cuboid bone, as this can always be readily found if the knife is introduced behind the prominence of the fifth metatarsal bone, and the incision is directed obliquely forward and inward. According to Bergmann, this joint coincides with the direction of a line passing from the tuberosity of the fifth metatarsal bone to the head of the first metatarsal bone. After this first joint has been opened, the course of the remainder of the complex articular line can be made out from the landmarks mentioned. The operator therefore directs his knife more toward the middle line of the foot and opens the almost transverse joint between the cuboid bone and the fourth metatarsal.

The next also transverse joint is situated somewhat further forward. The transverse line of the joint between the second metatarsal bone and the middle cuneiform bone is readily found, corresponding with a prolongation inward of the articular line of the fourth metatarsal bone (Fig. 71). The joint between the first metatarsal bone and the internal cuneiform bone also is situated further forward. The articular surfaces must be exposed by short incisions directed against the bone. The longitudinal articular surfaces are likewise exposed, and with increasing plantar flexion of the foot the short ligaments that unite the bones in the depth, as well as the ligaments of the sole, in so far as these fall within the range of the incision, are divided, until the whole series of joints is opened to a maximum degree. It is now still necessary to form a plantar flap. This must be so constituted as to include at its base the soft parts of the entire sole. The substance of the flap gradually diminishes in amount toward its periphery, so that at its extremity it consists only of skin and subcutaneous connective and fatty tissue, and it is

EXARTICULATION OF THE FOOT BY LISFRANC'S METHOD.

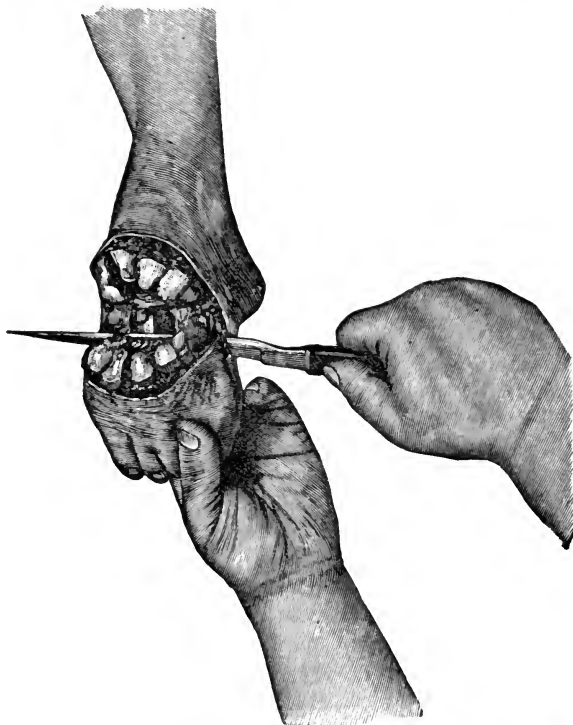


FIG. 72.—The foot is flexed on the sole at Lisfranc's joint: formation of the plantar musculotegumentary flap by incision from within outward.

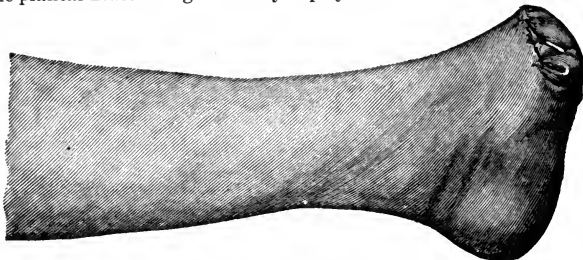


FIG. 73.—Stump left by Lisfranc's operation.

thus readily united with the delicate skin of the dorsum of the foot. With a long knife an incision is made horizontally through the sole around the sesamoid bones at the head of the metatarsal bone of the great toe the knife being brought out of the wound transversely beyond the heads of the metatarsal bones (Figs. 72, 73, 74). The *dorsalis pedis* and the internal plantar artery are to be ligated in the stump.

The stump left by Lisfranc's operation yields good functional results. The flap is firm and well padded, and the cicatrix is situated upon the dorsal aspect, quite out of the area of the walking-surface. The extensors of the

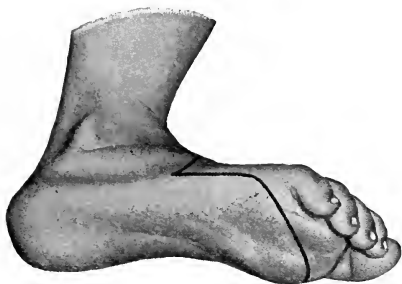


FIG. 74.—Form and extent of the plantar flap in Lisfranc's operation.


ankle-joint (*tibialis anticus*, *peroneus brevis*), important as antagonists of the triceps, are maintained in their attachments.

Intertarsal Amputation.—The joint between the anterior surface of the scaphoid bone and the three cuneiform bones is opened, and the cuboid bone is sawed through transversely in the lateral prolongation of the joint named. The cutaneous incisions are the same as in Lisfranc's operation. The joint in front of the scaphoid bone, recognizable by its articular surface with three facets, is opened from the dorsum of the foot and made to gape widely. The periosteum upon the dorsal surface of the cuboid bone is incised transversely, and the bone is divided

Plate 9.—Chopart's Articular Line.

T, astragalus ; *N*, scaphoid bone ; *K*, calcaneum ; *Cu*, cuboid bone ; *L*, calcaneoscaphoid ligament.

transversely with the phalangeal saw. The foot is held in plantar flexion, and the plantar flap is made as in Lisfranc's operation.

Intertarsal Exarticulation of the Foot.—Chopart's Operation.—The astragaloscaphoid and the calcaneocuboid articulation constitute approximately a transverse line through which the foot may be divided within the tarsus. The extremity of this articular line upon the inner border of the foot lies just behind the tuberosity of the scaphoid bone ; while upon the outer side the calcaneocuboid articulation will be entered if the incision is made a thumb's breadth behind the tuberosity of the fifth metatarsal bone. Chopart's joint does not correspond with a transverse line uniting these two points, but presents the following curve : . The head of the astragalus is directed with its convexity forward, while the anterior articular surface of the os calcis is, on the contrary, excavated (Plate 9). The calcaneoscaphoid interosseous ligament maintains the bones in apposition after division of the articular capsule.

The operator occupies the same position as in Lisfranc's operation, and lateral incisions are made along the borders of the foot outlining the plantar flap, the posterior extremities of which are united by an incision passing transversely over the dorsum of the foot. The joint between the head of the astragalus and the scaphoid bone is always opened first. It is not to be mistaken, as its situation is indicated by the prominent head of the astragalus, in advance of which the incision is made, as well as by the tuberosity of the scaphoid bone, behind which the incision passes. In order to divide the *key to Chopart's joint* (the calcaneoscaphoid interosseous ligament) and to open the calcaneocuboid articulation, the point of the knife is inserted in the outer extremity of the already opened astragaloscaphoid articulation, and the blade is



directed toward the middle of the small toe, and the tensely stretched ligament is divided with a slight degree of pressure. The foot is flexed in the line of the open joint; the ligaments of the sole of the foot are divided in the line of the incision, and the plantar flap is made from the sole as in Lisfranc's operation, though correspondingly smaller, a finger's breadth behind the head of the metatarsal bone. In the stump the *dorsalis pedis* and the internal and external plantar arteries will require ligation.

If the directions given be not strictly followed, it is possible that instead of entering the line of Chopart

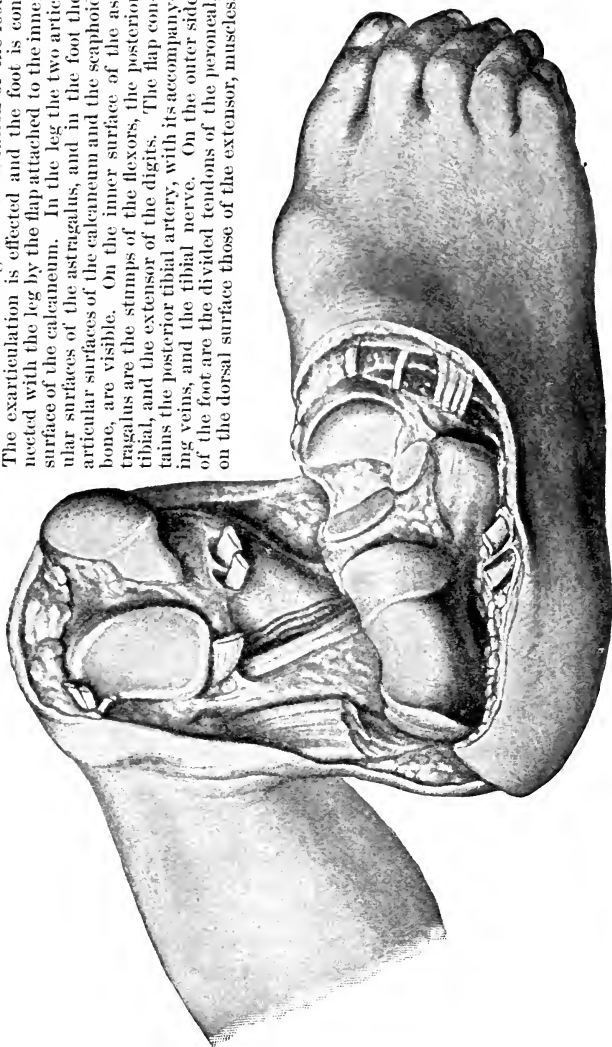


FIG. 75.—Subastragaloid enucleation of the foot: tegumentary incision.

the operator may enter that between the anterior surface of the scaphoid and the three cuneiform bones. The retention of the scaphoid bone would scarcely be a disadvantage, inasmuch as the posterior tibial muscle is attached to it. Jobert has recommended this method of prescaphoid enucleation as a regular procedure.

The stump left by Chopart's exarticulation has a ten-

FIG. 76.—Subastragaloid enucleation of the foot. The exarticulation is effected and the foot is connected with the leg by the flap attached to the inner surface of the calcaneum. In the leg the two articular surfaces of the astragalus, and in the foot the articular surfaces of the calcaneum and the scaphoid bone, are visible. On the inner surface of the astragalus are the stumps of the flexors, the posterior tibial, and the extensor of the digits. The flap contains the posterior tibial artery, with its accompanying veins, and the tibial nerve. On the outer side of the foot are the divided tendons of the peroneal, on the dorsal surface those of the extensor, muscles.



dency to fix itself in a position of club-foot. This defect, it is thought, can be overcome by certain modifications, such as Jobert's prescaphoid exarticulation, as well as intertarsal amputation, inasmuch as the attachment of the tibialis posticus muscle to the scaphoid bone is preserved,



FIG. 77.—Stump following Malgaigne's subastragaloid exarticulation.

and in consequence of which a force favorable to dorsal flexion is retained.

Subastragaloid Enucleation of the Foot (Textor, Günther, Malgaigne).—If after enucleation of the foot at Chopart's joint the calcaneum is additionally removed, the astragalus alone of the tarsus is left in connection with the

leg. This form of enucleation of the foot, which is known as *subastragaloid exarticulation of the foot*, was practised and introduced by Malgaigne as a regular procedure. In the original operation the incisions were like those in Syme's operation (p. 118), although the dorsal tegumentary flap extended beyond Chopart's joint. The foot was removed at this joint, and then the os calcis was extirpated. The best incision for *subastragaloid enucleation* is that of Günther, who employs an internal flap extending to the sole to cover the wound.

The incision (Fig. 75) begins over the tuberosity of the os calcis in the middle line of the heel, passes thence in an arched direction below the external malleolus, and turns at the level of Chopart's joint toward the median line, to continue transversely across the dorsum of the foot to its inner border, whence it courses over the sole of the foot to the middle line. From this point the incision is continued backward at an acute angle, through the skin of the sole, to reach the point of origin over the tuberosity of the os calcis. The incision everywhere reaches down to the bone.

The articulation between the head of the astragalus and the scaphoid bone is first opened, and then the connections between the astragalus and the os calcis are divided in the tarsal sinus. If the under surface of the astragalus is thus freed, the flap outlined is separated close to the bone from the inner surface of the os calcis, while the foot is rotated outward upon its longitudinal axis (Fig. 76). In opening the joint between the head of the astragalus and the concavity of the scaphoid bone the calcaneocuboid articulation should not be included within the range of the incision. The articulation between the trochlear surface of the astragalus and the bones of the leg should also be protected.

Amputation of the Leg.—The removal of the leg may be undertaken at any desired level. It was formerly the custom to amputate the leg under all circumstances in its upper third, five fingers' breadth below the knee-joint, at

the site of election. This method had for its object the use of a wooden leg, upon which the flexed knee was comfortably received after the wound had healed. At present, however, the principle is followed to be as conservative as possible in amputations of the leg, and to effect removal with the greatest care for the healthy portion of the extremity. For this reason amputations are no longer performed at the site of election, but at the site of necessity.

If the amputation-stump is to serve as a basis of support, it must be provided with a large walking surface and be able to carry the weight of the body without pain. Following the methods of amputation commonly applied to other members, with the formation of a cuff or of flaps from the soft parts, evidences of atrophy of the stump appear in the course of time, which, by reason of the resulting change in conformation, jeopardize its *supporting power*. Such a stump is, further, always more or less tender on pressure. These manifestations are not observed in stumps in which a segment of bone is brought in coaptation for union with the sawed surface, and in this way closure of the medullary cavity of the amputated bone is effected in the so-called *osteoplastic methods of amputation*. Stumps yielded by *Pirogoff's method of amputation of the leg* (p. 120) exhibit no alteration, even after the lapse of years, and retain wholly their supporting power. Bier has solved successfully the problem of securing stumps of equally permanent supporting power in the diaphysis of the leg. Originally, after the stump left by amputation of the leg had healed, a wedge of bone was excised in such a way that the extremity of the stump, when flexed at a right angle, formed a sort of foot, which furnished the patient an adequate base of support. The walking surface was thus constituted by the posterior aspect of the bones of the leg in their natural connection with the overlying soft parts. Further observation disclosed the noteworthy fact that the supporting power of a stump depends exclusively upon the nutrition of the sawed surface of the

bone. The closure of the latter by a periosteal-osseous flap is of distinct significance. Of less importance are the extent of the walking-surface, the situation of the cicatrix, as well as the requirement that the soft parts serving as the walking-surface should be retained in their natural connection with the bone. Bier has abandoned his original method and has described a method of osteoplastic amputation of the leg that can be performed in one stage.

Subperiosteal amputation of the leg by the method of Bruns (p. 117) also yields good results with regard to the supporting power of the stump.

The following methods for amputation of the leg are employed :

A circular incision in two steps, with the formation of a cuff.

Two lateral musculocutaneous flaps of equal or unequal size.

An anterior cutaneous-periosteal flap and a posterior short, musculocutaneous flap from the calf (Heine).

An anterior inner, cutaneous-periosteal-osseous flap (Bier, Eiselsberg).

An anterior and a posterior musculocutaneous-periosteal flap of equal length (Bruns).

In the performance of supramalleolar amputation one of the following methods may be employed :

A flap from the skin of the heel (Syme).

A cutaneous-periosteal-osseous flap from the heel (Pirogoff).

Amputation of the Leg with a Circular Incision in Two Steps.—After a circular incision has been made through the skin, an assistant rotates the leg toward the operator, who begins the dissection of the cuff at a point most remote from himself, and, progressing toward himself, he dissects the entire circumference of the part. When the cuff has been dissected free for a sufficient distance and folded back, and the line of reflection occupies a single plane, the layer of muscles is divided. The incision

through the muscles of the calf is made in three steps. Finally, the muscles upon either side of the interosseous ligament are divided. This complex incision should be made exactly in the same plane, so that the vessels are not divided at varying levels.

In making the figure-of-eight incision the knife is placed horizontally, with its heel upon the upper surface of the tibia, so that its pointed extremity is directed toward the operator. It is steadily held in a horizontal position and drawn from heel to toe, is introduced into the interosseous space close to the tibia up to its handle, and the soft tissues between the two bones are divided. The fibula being reached, the knife is drawn from heel to toe around this bone and is passed horizontally again into the interosseous space, with its point directed from the operator and its blade upward, dividing any remaining muscular fibers from the fibula toward the tibia. The operator now introduces the index-finger and the thumb into the wound and grasps the interosseous ligament to assure himself that all the muscles have been transversely divided. Before the saw is used the assistant rotates the member inward. The periosteum is detached from the bone with the raspatory at the line of division. The saw is applied upon the tibia in such a manner that the fibula also is brought within the range of its action. A groove is first carefully sawed in the tibia, and when the blade of the saw has thus secured a good grasp the fibula also is brought within the sphere of its activity, and both bones are divided simultaneously (Fig. 62).

The stump thus made (Plate 10) shows the cross-section of the two bones, with the interosseous ligament stretched between them. Anteriorly, lying upon the ligament, is the group of extensors, while upon the opposite side lie the flexors. Surrounding the fibula the peroneal group of muscles is visible. The powerful mass of the calf-muscles forms the most superficial layer upon the flexor aspect. Between this and the flexors pass the posterior tibial and peroneal arteries. Lying upon the anterior aspect of the

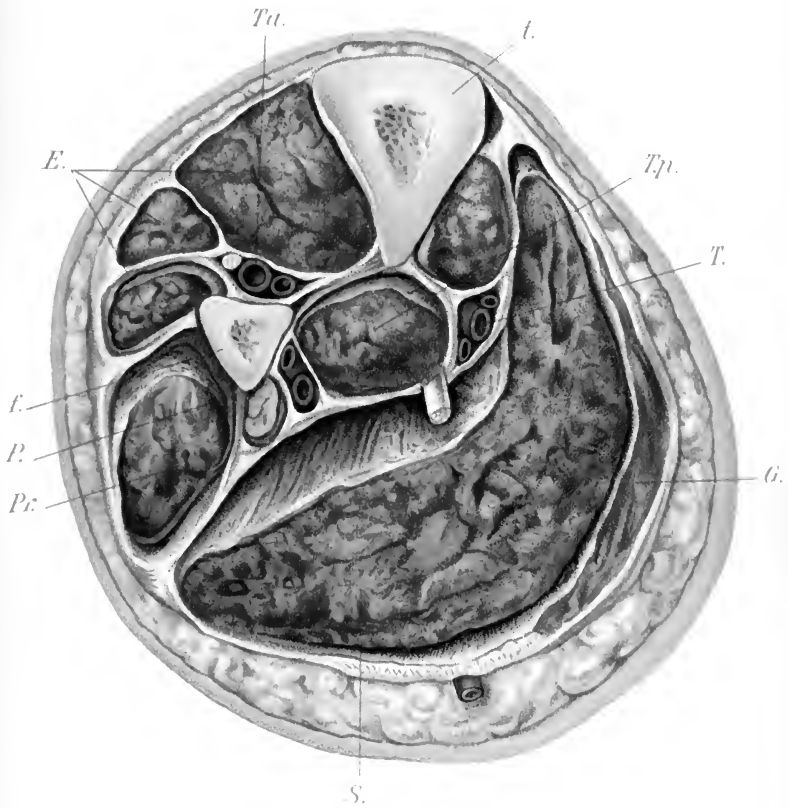
Plate 10.—Transverse Division of the Right Leg in its Middle Third.

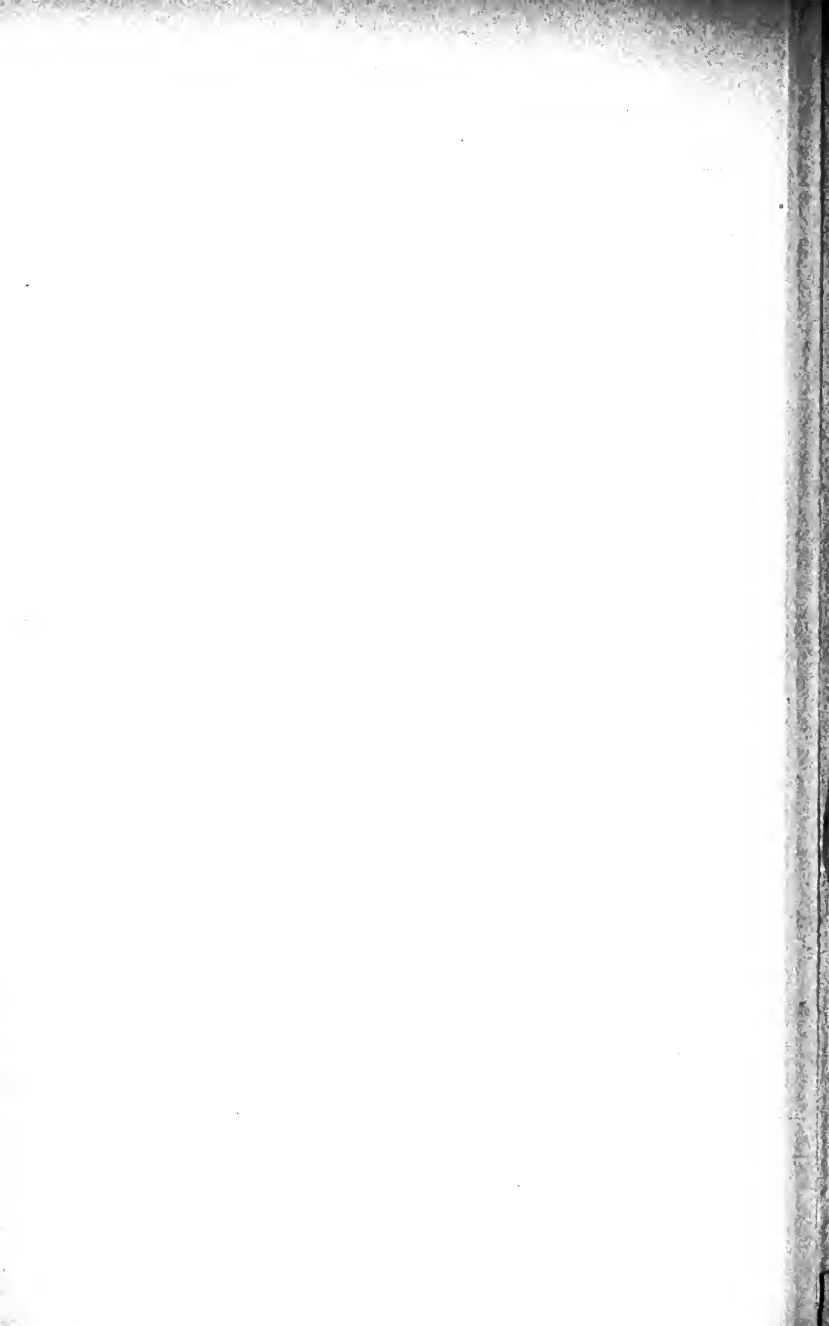
t, tibia; *f*, fibula; *E*, group of extensors (tibialis anticus, extensor digitorum communis, extensor hallucis); *S*, soleus; *G*, gastrocnemius; *Tp.*, tibialis posticus; *Pr.*, peronei; *Ta.*, anterior tibial artery, with the corresponding vein and the deep peroneal nerve; *T*, posterior tibial artery, with the corresponding veins and the posterior tibial nerve; *P*, peroneal artery and vein.

interosseous ligament is the anterior tibial artery. The center of the field is occupied by the tibialis posticus muscle, which is a useful landmark in looking for the vessels. In front of this, but separated by the interosseous ligament, is the anterior tibial artery, and closely behind it are the posterior tibial and peroneal arteries to the fibular and tibial sides respectively.

Flap-amputations of the Leg.—1. *Two Lateral Tegumentary Flaps of Equal Size.*—The base of the flaps corresponds with the level at which the bones are to be divided. Anteriorly the margins of the flaps meet in the line of the crest of the tibia. The shape of the flaps is outlined with the knife introduced down to the fascia, when the flaps are dissected from the subjacent structures and turned back (Fig. 66). The incisions through the muscles are to be made in the typical manner described at right angles to the axis of the extremity. The muscles of the calf are divided in three steps; then those of the interosseous space by the figure-of-eight incision; finally the bone is divided in the manner described. To prevent the projection of the sharp anterior crest of the tibia after division with the saw this prominence is either broken off with forceps or sawed off. To this end the crest is sawed into in an oblique direction, from above downward and backward, for some distance, before the bone is removed. When the tibia is now divided transversely, a portion of the bone at the crest falls out and the anterior prominence is removed.

2. *Two Lateral Musculotegumentary Flaps.*—The shape of the flaps is the same as that just described. An incision





is made through the skin and the fascia down to the muscle. After the skin has been retracted the flaps are formed either by transfixion or by incision from without inward. When the flaps are folded back the muscles are divided

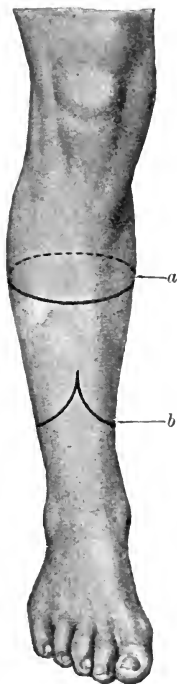


FIG. 78.—Incisions for amputation of the leg: *a*, circular incision for amputation at the site of election; *b*, lateral flap-incisions.

by a figure-of-eight incision and the bone is sawed through at the level of the base of the flaps.

A *single lateral flap* is made correspondingly longer and with a broader base. It may be constituted of skin, on the inner side of skin and periosteum, or finally of skin and muscle. When the flap has been dissected, a circular incision through the skin is made upon the opposite portion of the circumference of the leg, uniting the extremi-

ties of the flap, and after retraction of this the muscles are divided in the usual manner.

Amputation of the Leg According to the Method of Heine.
—Anterior Long Tegumentary-Periosteal Flap, with a Posterior Short Musculotegumentary Flap.—A broad quad-



FIG. 79.

FIG. 80.

FIGS. 79, 80.—Cutaneous incisions for amputation of the leg, showing anterior and lateral aspects (after Heine).

angular flap with rounded corners is made upon the anterior aspect of the leg (Figs. 79 and 80). In the situation where the flap, after division of the skin, retracts, the periosteum of the anterior surface of the tibia is incised transversely, parallel with the lower border of the flap.

The skin is dissected from the subjacent tissues from either side of the flap toward the tibia, and the periosteum of

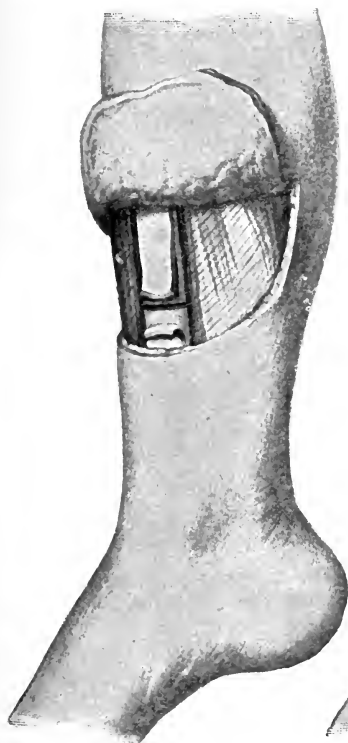


FIG. 81.

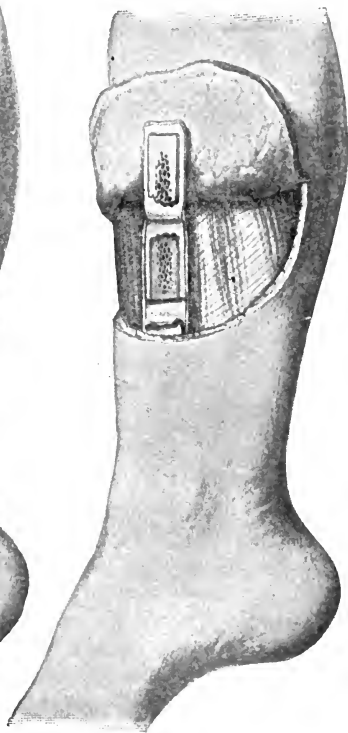


FIG. 82.

OSTEOPLASTIC AMPUTATION OF THE LEG.

FIG. 81.—Cutaneous flap; division of periosteum.

FIG. 82.—Periosteal-osseous flap from the surface of the tibia, reflected upward.

the tibia along its lateral border is divided longitudinally. In the process of dissecting the flap, the periosteum is detached from the bone by means of a raspatory and thus

retains its connection with the freed skin. After the anterior flap has been dissected to its base, the member is raised and a shorter arched flap consisting of the skin and the muscles of the calf is formed upon the posterior aspect of the leg by an incision from without inward. The muscles of the interosseous space are then divided, and the bones are sawed through in the usual manner.

Osteoplastic Amputation of the Leg According to the Method of Bier and Eiselsberg.—An *anterior and inner cutaneous flap* is outlined, with its base corresponding to

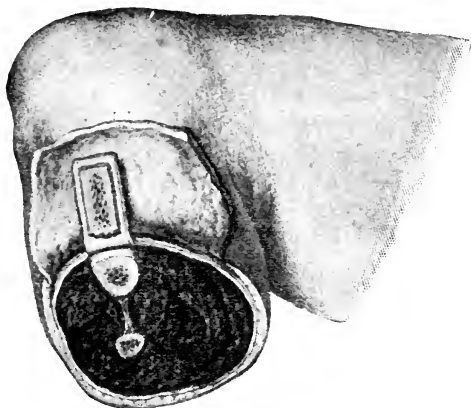


FIG. 83.—Osteoplastic amputation of the leg : leg removed at the level of the reflection of the bone-flap.

half of the circumference of the leg and its length to the diameter of the leg. The tongue-shaped cutaneous flap thus formed is dissected from the subjacent tissues and reflected upward (Fig. 81). The periosteum of the tibia is incised transversely at the level of the apex of the flap, and longitudinally along the borders of the bone. In the area of the transverse incision a small wedge is sawed from the bone, and from the depression thus formed a disk from 2 to 4 mm. is sawed from the tibia parallel with its anterior surface. The bone-flap is made from 5 to 8

cm. long, accordingly as the sawed surface of the tibia only or that of the fibula also is to be covered. After the disk of bone has been sawed out of sufficient length, it is fractured at its base and reflected upward (Fig. 82). The lateral, longitudinal incisions in the periosteum are prolonged upward for several centimeters. After the periosteum at the base of the bone-flap has been detached from the surface of the tibia for a short distance, the flap will have been rendered sufficiently mobile. The two upper extremities of the cutaneous flap are united by a semi-circular incision around the posterior circumference of the leg, and division of the leg is effected at the same level in

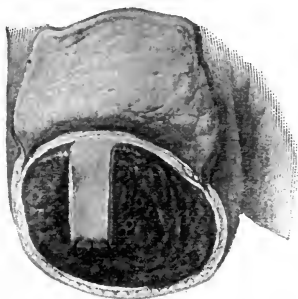


FIG. 84.—Osteoplastic amputation of the leg: fixation of the periosteal osseous flap upon the sawed surface of the leg.

accordance with established rules (p. 82). The periosteal-osseous flap can be applied like a lid to the sawed surface, to which, after ligation of the vessels, it is attached by silk sutures that unite the periosteum of the flap with that of the stump of the tibia and to the muscles. The cutaneous wound is closed by sutures (Figs. 84 and 85).

Subperiosteal Amputation of the Leg According to the Method of Bruns.—The operator retracts the skin of the leg, and by means of a circular incision divides all the soft parts down to the bone. On the inner and outer surfaces an incision 4 cm. long is made upon the crest of the tibia and the fibula. Through these longitudinal incisions

the bones are carefully freed from their periosteal sheath by means of a raspatory, so that the muscles in the flap retain their natural connection with the periosteum (Fig. 65). The division of the bone is effected at a point corresponding to the upper extremity of the longitudinal incisions. The periosteum and the muscles are united by buried sutures, and the wound in the skin is closed separately by suture. It is the consensus of opinion that useful stumps result from the employment of this method. The good conformation of the stump is permanent and is not inferior to that yielded by osteoplastic procedures.

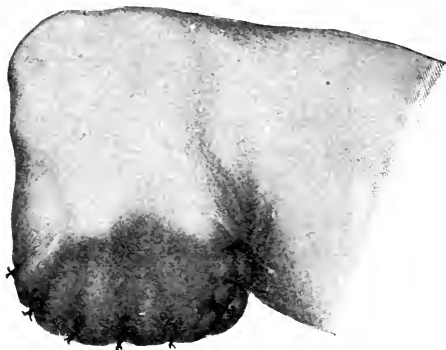


FIG. 85.—Osteoplastic amputation of the leg: amputation-stump.

Supramalleolar Amputation of the Leg by Syme's Method.

—The ankle-joint is opened, the bones of the leg are divided just above the malleoli, and the wound is covered with a cutaneous flap obtained from the heel. The patient occupies the dorsal decubitus. The foot is raised above the horizontal, and the operator stands on its peripheral side. Grasping and fixing the foot by the heel with his left hand, the operator makes an incision, always beginning on the left side, from the apex of the malleolus vertically toward the sole of the foot, then transversely across the sole, and again vertically upward to the other


malleolus, dividing the tissues down to the calcaneum (stirrup-incision, strap-incision). A second incision, made over the anterior aspect of the ankle-joint, unites the extremities of the first, with which it makes a right angle, and it also extends down to the bone. This incision should open the joint between the trochlear surface of the astragalus and the lower extremity of the tibia and the fibula. In order to expose the joint fully the lateral ligaments must be divided on either side. The incision through the capsule will accordingly have the following form: , the lateral limbs passing through the lateral ligaments. Only after the lateral ligaments (at the outer malléolus, the anterior and posterior astragalo-



FIG. 86.—Amputation of the foot by the method of Syme: enucleation of the tuberosity of the calcaneum from its coverings.

fibular, and the calcaneofibular; at the internal malleolus, the deltoid ligament) have been divided will the head of the astragalus be free, even with slight plantar flexion of

the joint. If the posterior wall of the capsule be divided, the upper surface of the calcaneum comes into view. The tuberosity of the calcaneum is freed from its coverings by vigorous incisions made vertically upon the bone, with the foot bent in maximum plantar flexion (Fig. 86). When the foot is thus freed and detached the lower extremities of the tibia and the fibula are freed from the soft tissues, surrounded by a circular incision, and sawed through transversely.

The operation is attended with certain disadvantages, the excavated heel-flap not being properly adapted to approximation with the leg, while the excavation is further favorable to the accumulation of considerable quantities of secretion. Although Syme's operation no longer receives the recognition which was formerly accorded it, it still deserves consideration, as it represents the basis of a number of admirable methods of amputation (Pirogoff, Gritti, etc.).

Amputation of the Foot by the Method of Pirogoff.—Pirogoff's operation consists in osteoplastic supramalleolar

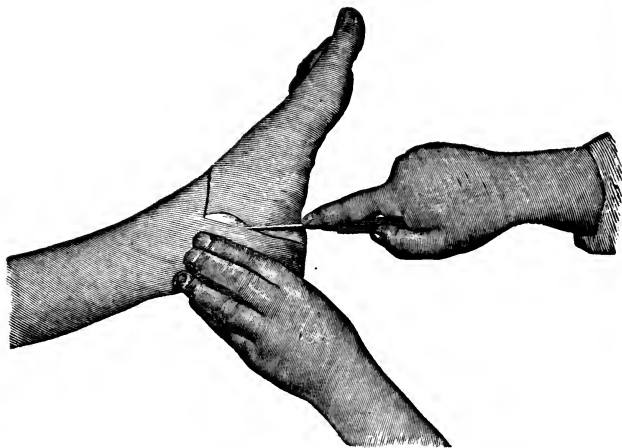


FIG. 87.—Pirogoff's amputation, I.: cutaneous incisions.

amputation of the leg, with the formation of an osseous-tegumentary flap from the heel. This procedure over-

comes the disadvantages and difficulties of Syme's operation by not separating the tuberosity of the calcaneum, but sawing through the bone so that its posterior segment retains its connection with the skin and enters into the formation of the flap. The operator occupies the same position as in the operation of Syme and the incisions through the skin are made in a similar manner. The operator fixes the foot with his left hand and, beginning on the left side, cuts from the apex of one malleolus vertically toward the sole of the foot (Fig. 87), then trans-

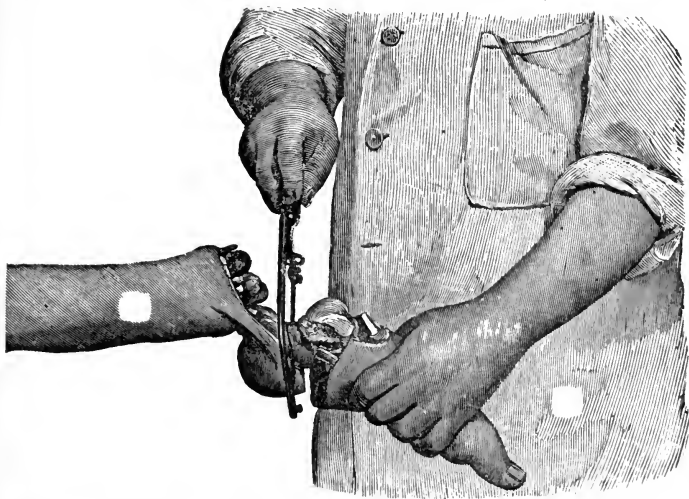


FIG. 88.—Pirogoff's amputation, II. : division of the calcaneum with the saw.

versely through the sole, and again vertically upward to the apex of the other malleolus, dividing the soft tissues down to the bone (stirrup-incision). An anterior transverse incision unites the extremities of the primary stirrup-incision. This incision divides the tendons of the extensors transversely and opens the capsule of the ankle-joint. In order to open widely the joint between

the head of the astragalus and the lower extremities of the tibia and the fibula the lateral ligaments must first be

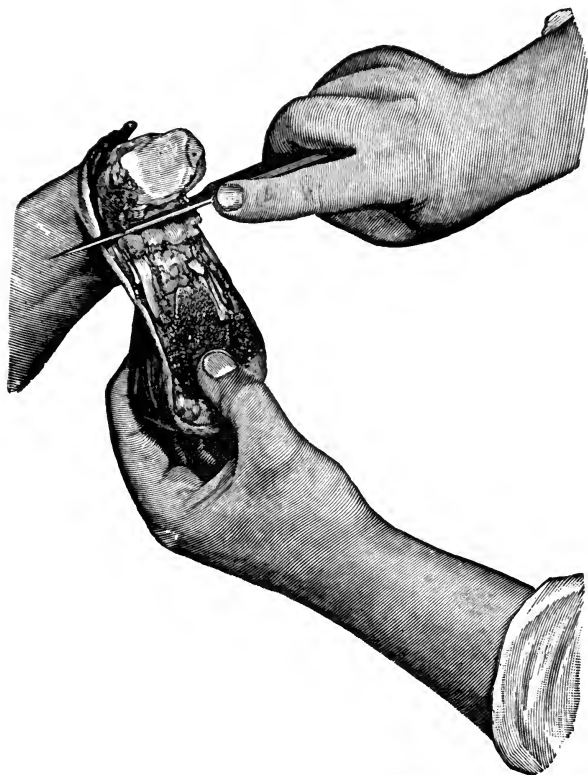


FIG. 89.—Pirogoff's amputation, III. : detachment of the soft parts from the posterior aspect of the lower extremity of the leg ; the blade of the knife is directed against the bones.

divided. In effecting this division, especially upon the inner aspect, the incision should be made close to the astragalus, in order to avoid injuring the posterior tibial artery. After the joint has been freely exposed the



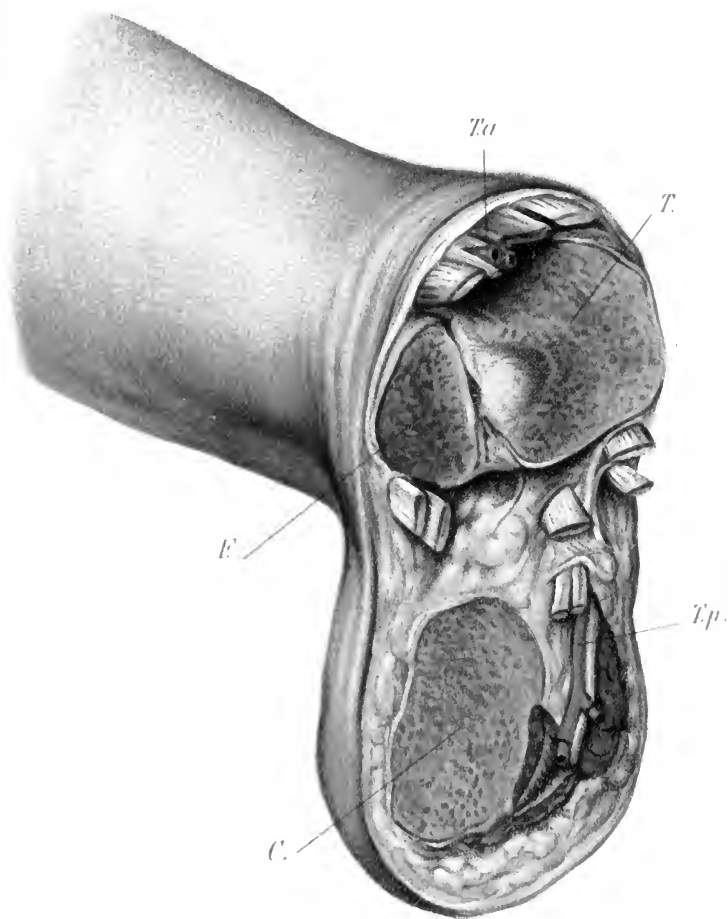
FIG. 90.—Pirogoff's amputation, IV. : division of the bones of the leg with the saw ; the external malleolus is grasped and fixed with Langenbeck's forceps.

**Plate 11.—Amputation of the Foot by the Method of Pirogoff
(Right foot).**

Configuration of the wound after removal of the foot. The sawed surfaces of the bones of the leg (*T. F.*) and the dependent heel-flap with the cut surface of the calcaneum (*c*) are visible. The posterior tibial artery and vein (*Tp.*) are situated on the inner side of the flap, the anterior tibial artery (*T. a.*) on the extensor aspect of the leg, between the extensor hallucis longus and the extensor digitorum communis.

posterior wall of the capsule comes into view, after division of which the upper surface of the tuberosity of the calcaneum is exposed. The operator, who until now has stood at the periphery of the foot, changes his position, grasps the foot with his left hand and applies the saw to the upper surface of the tuberosity of the calcaneum (Fig. 88). This process is divided in a plane corresponding to that of the stirrup-incision, when the foot appears to be separated. The lower extremities of the tibia and the fibula are prepared for division with the saw, the soft parts upon the posterior aspect being first dissected close to the bone. This incision demands especial care in order to avoid division of the posterior tibial artery, which is essential for the nutrition of the heel-portion of the flap. The surgeon grasps the flap between the thumb and the index-finger of his left hand, flexes it backward in maximum degree and separates the soft parts from the posterior aspect of the tibia by keeping the blade of the knife in direct contact with the bone (Fig. 89)

Upon the anterior surface it suffices to displace the tendons, when the bones of the leg may be divided circularly just above the malleoli. In sawing through the bones the leg is held horizontally, the operator standing as if amputating, with the member to be amputated to his right. An assistant grasps the external malleolus with Langenbeck's forceps, when the division of the bone transversely to the longitudinal axis of the leg may be proceeded with (Fig. 90). The stumps of the tendons are grasped with forceps and divided with scissors at the level



of the wound. The vessels are secured by ligatures. The only vessels concerned are the anterior and posterior tibial arteries. The first is readily found upon the anterior surface of the tibia at the side of the tendon of the extensor

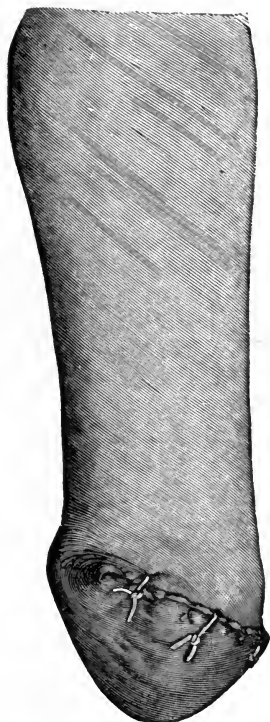


FIG. 91.—Stump left after Pirogoff's amputation.

hallucis. If the successive steps of the operation have been properly followed, the posterior tibial artery will be found to have been divided transversely on the inner aspect of the heel-flap, somewhere about the middle of the vertical limb of the stirrup-incision (Plate 11). In

closing the wound the heel is moved through an arc of 90° and the sawed surface of the calcaneum is brought in simple apposition with that of the tibia and fibula or fixed by bone-sutures or percutaneous pegs. The cutaneous wound is united transversely (Fig. 91).

The operation of Pirogoff has undeniable advantages over such an amputation of the leg as Syme devised. The shortening is reduced to a minimum by the preservation of the posterior extremity of the calcaneum, which forms a continuation of the bones of the leg. The strong, well-cushioned skin of the heel makes an admirable walking-surface, while the cicatrix does not lie within this area. The stump is eminently useful.

Pirogoff in his first communication upon the subject had already called attention to the fact that after making the incision into the sole of the foot the division of the calcaneus could be proceeded with immediately from the sole (Figs. 92 and 93), and exarticulation at the ankle-joint next effected. He had also made the suggestion to give an oblique direction to the heel-flap in order to include a larger portion of the calcaneum and the skin of the sole into the posterior flap. These modifications have been elaborated by Günther and Lefort.

While the cutaneous incisions and the planes of the two incisions through the bones are at right angles to each other in Pirogoff's operation (Fig. 94), the tuberosity of the calcaneum is divided obliquely from behind above forward and downward in Günther's modification; also, the lower extremities of the tibia and the fibula are not separated in the form of a plate, but in that of a wedge, and in such a manner that the base of the wedge corresponds with the posterior and the apex with the anterior boundary of the tibia (Fig. 95). As a matter of course, the cutaneous incisions are to be modified accordingly. The stirrup-incision will pass from the posterior boundary of the malleoli, not vertically downward, but obliquely forward toward the sole, so that a larger portion of the skin of the sole is contained in the heel-flap. The stump

GUNTHER'S MODIFICATION OF PIROGOFF'S AMPUTATION.



FIG. 92.—Division of the calcaneum from the sole of the foot.

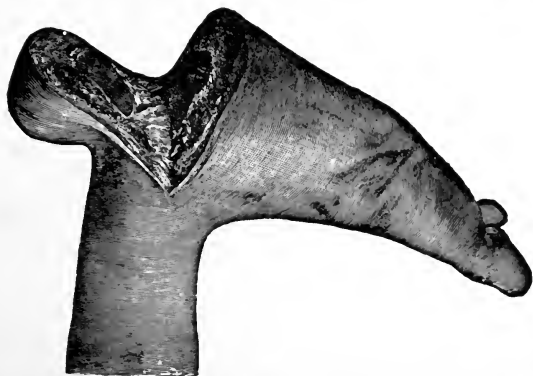


FIG. 93.—Configuration of the foot after division of the calcaneum.

is thus changed in so far that not only does the tuberosity of the calcaneum form the walking-surface, but also a portion of the sole, the natural walking-surface, serves as a support for the stump.

The walking-surface becomes still broader if the calcaneum is divided almost horizontally, in accordance with the modification of Lefort (Fig. 96). The stirrup-incision passes obliquely forward to Chopart's joint, while the dorsal incision forms a flap with its convexity directed forward, likewise extending beyond the line of Chopart's joint. The dorsal flap is dissected back, the ankle-joint opened, and the calcaneum sawed through from its tuberosity forward in the direction of the cutaneous incision into the calcaneocuboid joint, the foot being held in a position of maximum plantar flexion. The foot is now separated at Chopart's joint, and the lower extremities of the tibia and fibula are divided in the manner described.

Bruns recommends horizontal division of the calcaneum, though in an arched direction. The sawed surface of the calcaneum is thus concave, while that of the tibia presents a corresponding convexity.

The limitations of Lefort's modification are naturally narrower than those of the typical operation of Pirogoff. If the calcaneum is perfectly healthy—and this is a necessary condition for the employment of Lefort's operation—it would seem preferable to select the less serious procedure of exarticulation at Chopart's joint.

As a preliminary step in the performance of Pirogoff's operation division of the tendo Achillis (**Achillototomy**) is undertaken. The tendon is divided, either through an open wound or subcutaneously, a finger's breadth above its attachment to the tuberosity of the os calcis.

In performing subcutaneous tenotomy the knife (tenotome) is passed through the skin, and the tendon is divided by cutting either toward or from the skin. Under the condition first named the operator grasps the tenotome

PLANE OF THE SAWED SURFACES IN PIROGOFF'S OPERATION.



FIG. 94.—Original method.

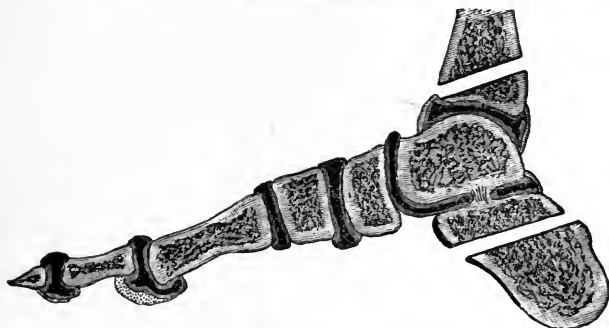


FIG. 95.—Günther's modification.

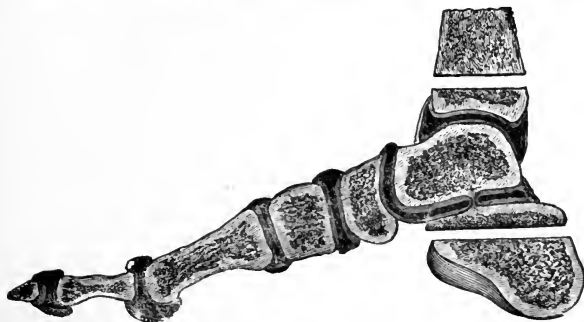


FIG. 96.—Lefort's modification.

as a table-knife is held in paring fruit, with the flexed four fingers of the right hand, while the thumb is supported on the heel (Fig. 97); the knife is passed from right to left in front of the tendon. The latter is subjected to passive tension and is divided by short rocking movements of the knife toward the thumb, which is



FIG. 97.—Achillotenotomy: the tenotome is passed beneath the relaxed tendon.

placed upon the tendon as a guide and to afford resistance (Fig. 98). The jerk with which the extremities of the divided tendon separate indicates the completion of the operation.

The tenotome is held differently when the tendon is to be divided from without inward. The foot is so adjusted



FIG. 98.—Achilliotenotomy: the extended tendon is divided in the direction of the skin, with the thumb of the operating hand resting upon the tendon.

that the tendon is completely relaxed. The tenotome is grasped between the thumb, the index, and the middle finger and introduced upon the flat, from right to left, between the skin and the tendon (Fig. 13). The tendon is thus brought beneath the blade of the knife and is divided by gentle rocking movements, while an assistant subjects it to maximum tension by appropriate movement of the joint.

Exarticulation of the Leg at the Knee-joint.—An anterior tegumentary flap is made upon the extensor aspect of the

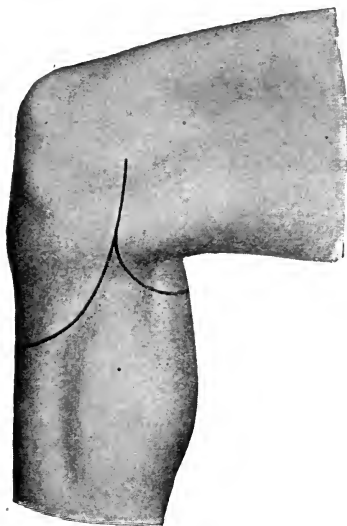


FIG. 99.—Enucleation at the knee-joint: outline of the flaps.

leg, and the joint opened from this surface. A short musculotegumentary flap is formed upon the flexor aspect by an incision from the wound outward. The tegumentary flap has a broad base, and its lower extremity extends below the tuberosity of the tibia (Fig. 99).

The operator stands at the periphery of the member. The anterior flap is outlined by incision with the knife.

The incisions, passing vertically downward from the most prominent points of the external and internal condyles of the femur, extend three or four fingers' breadth below the tuberosity of the tibia, at which level they are united by a transverse incision. The corners of the flap thus formed are rounded. The flap is now dissected from the subjacent structures to the level of the patellar ligament. With the extremity flexed at the knee the operator grasps the leg with his left hand, divides the patellar ligament with a single transverse incision, and opens the joint. The lateral ligaments and the crucial ligaments of the knee-joint are next divided, so that the leg is attached to the thigh by only the posterior wall of the capsule of the joint and the soft parts of the popliteal space. A long knife is introduced into the wound behind the tibia, and its edge is directed toward the periphery of the extremity, avoiding the head of the fibula, a short musculotegumentary flap being formed from the soft parts of the flexor aspect by incision from within outward. By these means the popliteal artery is not divided till the last stage of the operation. The patella remains connected with the anterior flap. A disadvantage of this method of operation consists in the necrosis at the margin of the flap that is frequently observed.

Pollosson recommends that the operation be so performed that the capsule of the joint is opened close to the tibia in order that after separation of this bone the capsule may be again closed by suture. In this way a cavity is formed above the stump. Recovery is said to take place promptly and the stump is believed to gain in usefulness.

Amputation of the Thigh.—Among methods of amputation of the thigh that may be employed advantageously are: the circular incision in two steps, with the formation of a cuff; and two equal-sized musculotegumentary flaps, one anterior and one posterior, or a long anterior and a short posterior musculotegumentary flap. The thigh may be amputated at any level. In operations involving the condyles, as in trancondylar amputation, *osteoplastic procedures* may be advantageously employed in order to secure a more useful stump.

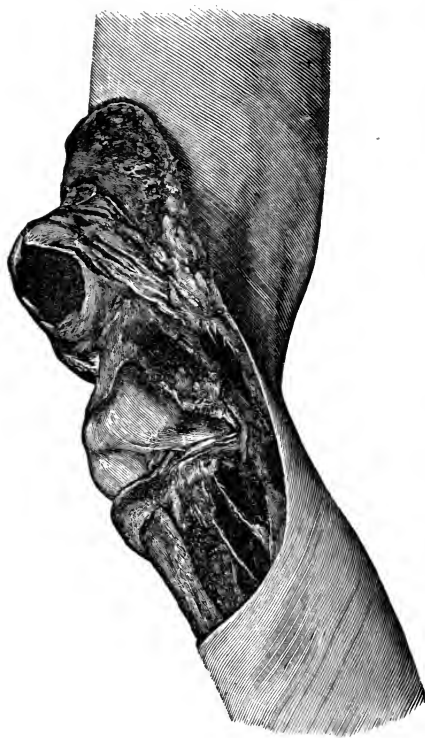


FIG. 100.—Amputation of the thigh according to the method of Grritti. The anterior flap is dissected free, and the patella is denuded.



FIG. 101.

FIGS. 101 AND 102.—Amputation of the thigh according to the method of Gritti. before and after union of the wound.

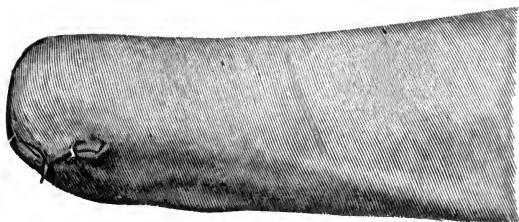


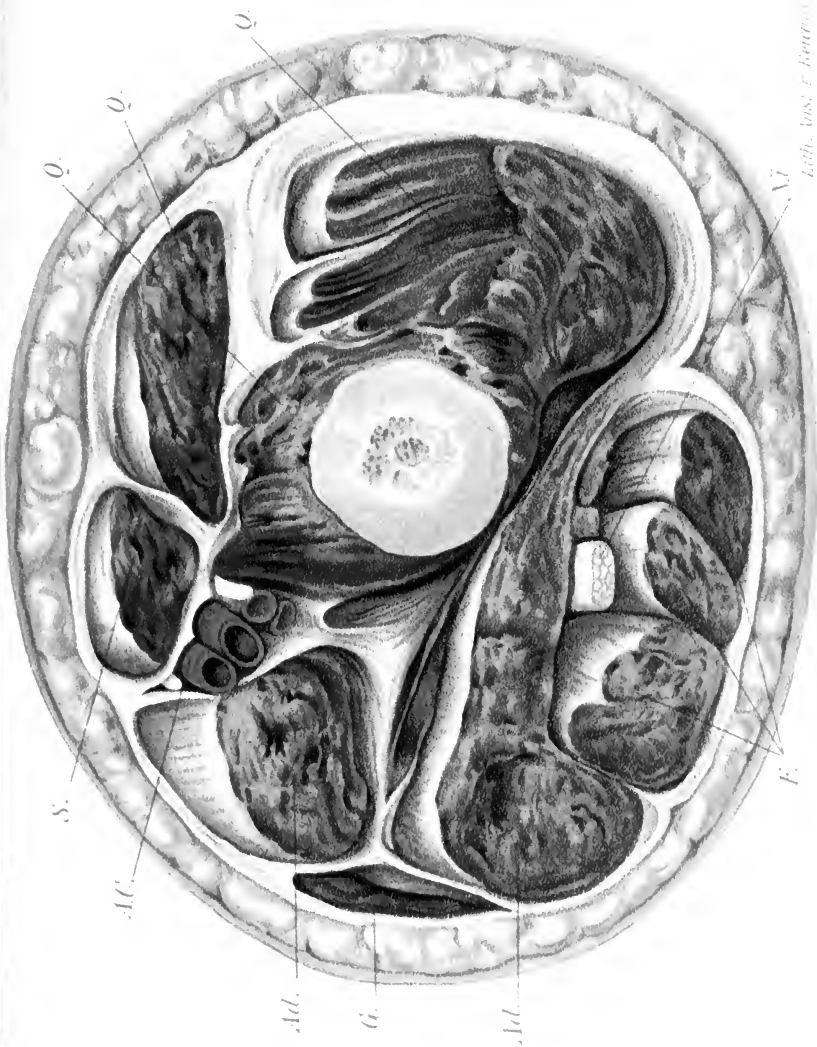
FIG. 102.

Configuration of the stump

Plate 12.—Transverse Incision through the Left Thigh at its Middle Third.

Q, quadriceps femoris muscle; *S*, sartorius; *Ad*, group of adductors; *F*, group of flexors; *G*, gracilis; *A.C.*, femoral artery in a common sheath with the profunda artery, the femoral veins, and the saphenous nerve; *Ni*, sciatic nerve.

Amputation of the Thigh by Means of a Circular Incision in Two Steps.—The pelvis of the subject is brought to the edge of the table. In amputating the right thigh the operator stands upon the outer side; and in amputation of the left thigh, upon the inner side of the extremity, which is held securely in a horizontal position. At a sufficient distance toward the periphery from the point at which the bone is to be divided a circular incision is made through the skin down to the fascia, and a cuff is turned back. At the point of reflection of this cuff the muscles are divided down to the bone in four steps with vigorous strokes of a long knife. The bone is divided with the saw at a point somewhat proximal to the incisions through the muscles. For this purpose the operator, with the index-finger and thumb of his left hand, pushes back the muscles upon the bone and divides the latter somewhat further from the periphery. The periosteum in the line of the incision is detached from the bone by means of a raspator, and the bone is divided with a saw, while the muscles of the stump are retracted by means of either tenacula or a divided bandage. In the center of the stump (Plate 12) may be seen the transverse section of the femur, around which the muscles are so grouped that upon the anterior surface lies the quadriceps femoris, while upon the posterior surface lie the flexors. To the inner side the group of adductors lie wedged between the flexors and the extensors. The depression between the adductors and the extensors is covered by the sartorius muscle. In the space enclosed by these muscles, which is triangular on cross-section, are to be found the femoral artery and vein, as well as the saphenous nerve. Between the flexors



is the sciatic nerve, always accompanied by vessels. In the connective-tissue interstices of the muscles are small arterial vessels divided transversely or visible in longitudinal section. After permanent control of hemorrhage the muscles are to be so united by buried sutures that the formation of cavities and dead spaces is avoided. The skin is united by deep and superficial sutures.

Flap-amputations of the Thigh.—*Anterior and Posterior Musculotegumentary Flaps.*—The flaps are semicircular and well rounded. Both flaps meet upon the lateral aspects of the thigh in such a manner that the base of each corresponds to half the circumference of the part. The operator marks the outlines of the flaps by incisions passing through skin, fatty connective tissue, and the fascia lata, down to the muscles. Both flaps may be formed by transfixion or by incision from the periphery to the base. The flaps are reflected at their bases, and the muscles attached to the bone are divided by a circular incision. The bone is sawed through in the usual manner and the wound is closed by suture.

Osteoplastic Supracondylar Amputation of the Thigh.—*Supracondylar Amputation by the Method of Gritti.*—Gritti has ingeniously applied the osteoplastic principle of Pirogoff's operation to amputations at the knee-joint, the freshened surface of the patella being approximated to the sawed surface of the femur, in order that union may take place (Figs. 103, 104).

Mode of Procedure.—An anterior flap is made as for exarticulation of the leg (p. 87). This is dissected free to the level of the patellar ligament, and the joint is opened transversely in this situation. At the same time the lateral attachments of the capsule fastened to the condyles of the femur are divided, so that the flap, with the contained patella, can be reflected. The patella is surrounded by an incision on the synovial surface of the flap, and freshened by removal of its cartilaginous articular surface with the phalangeal saw (Fig. 100). The flap is now somewhat retracted, so that the supracondylar portion

of the femur is exposed. The bone is surrounded by an incision in this situation, and is sawed through, and a short musculotegumentary flap is formed from the soft parts of the popliteal space by an incision from within outward. The patella is approximated to the sawed surface of the femur and fixed in this situation by bone-sutures or percutaneous pegs. The stump (Figs. 101, 102) is functionally useful by reason of the closure of the medullary cavity of the femur with bone and the favorable situation of the cicatrix.

Modifications of Gritti's Operation.—A number of modifications of Gritti's method of osteoplastic amputation of the lower extremity of the femur have been proposed, in which, in place of the freshened patella, portions of the upper extremity of the tibia have been brought in apposition with the sawed surface of the femur for the purpose of obtaining union. It is of especial importance in the latter event that by retention of the upper extremity of the tibia the attachments of muscles are preserved that in Gritti's operation are separated from their insertion, and this is not without bearing upon the functional result.

Ssabanajeff has recommended inclusion in the flap of a segment of bone from the anterior portion of the tibia, together with the attachment of the rectus femoris muscle. A longitudinal incision is made from the most prominent point of each condyle of the femur, extending two fingers' breadth below the tubercle of the tibia, where both are united by a transverse incision. A short flap is outlined in the popliteal space with an arched incision and dissected free, the knee-joint being opened from the popliteal space. The leg is so bent at the knee-joint that the surface of the tibia is brought in apposition with the anterior aspect of the thigh. From the articular surface a plate of bone is removed from the upper extremity of the tibia by a transverse incision to below the tubercle, and this remains connected with the anterior flap. The femur is further divided transversely through its condyles. The supporting surface of the stump is thus formed by the tuberosity

DIAGRAMMATIC REPRESENTATION OF GRITTI'S OPERATION.

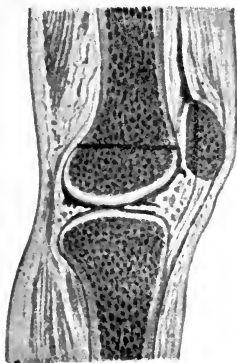


FIG. 103.

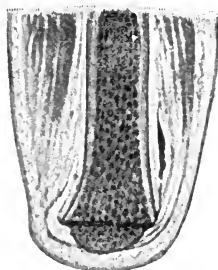


FIG. 104.

FIG. 103.—Direction of the sawed surfaces of the femur and the patella.
 FIG. 104.—Configuration of the stump.

DIAGRAMMATIC REPRESENTATION OF SSABANAJEFF'S OPERATION.

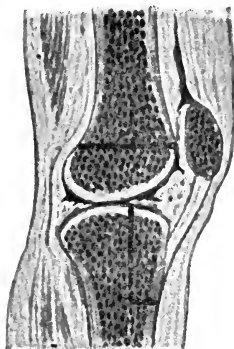


FIG. 105.

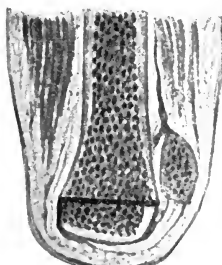


FIG. 106.

FIG. 105.—Direction of the sawed surfaces.
 FIG. 106.—Configuration of the stump.

of the tibia, and clinical reports (Koeh, Ehrlich) are in accord in the statement that it serves this purpose admirably (Figs. 105, 106).

The insertions of the muscles to the tibia are preserved in still greater degree by the modification of Djelitzyn. In any event the functional usefulness is greater, inasmuch as the muscles controlling jointly the movements of the hip-joint and the knee-joint, if preserved, retain their capability in the stump of acting as extensors or flexors of the hip-joint. An anterior flap is outlined according to the modification of Ssabanajeff, and from without inward a wedge of bone is sawed from the upper extremity of the tibia, so that also the head of the fibula is preserved. On the wedge-shaped segment of the tibia thus formed, in addition to the rectus, the insertions of the sartorius, gracilis, semitendinosus, and semimembranosus, and upon the head of the fibula also that of the biceps femoris, are preserved. The cutaneous osseous flap is reflected upward, the femur is sawed through, its condyles at right angles to the surface of the tibia, and a short flap is cut from the soft parts of the popliteal space (Figs. 107 and 108).

In cases in which the anterior surface of the leg is not adapted to the formation of a flap, the modification of Abrashanow is applicable. An anterior soft flap contains the denuded patella, as in the modification of Gritti, while a large posterior flap contains a segment of the tibia. The broad surface of the tibia is brought into coaptation with the femur, while the patella is approximated for union to the peripheral sawed surface of the tibia (Figs. 109 and 110). The better nutrition of the posterior flap, which contains the popliteal vessels, is a safeguard against necrosis of the flap, which may readily occur after employment of the other methods.

Exarticulation of the Femur at the Hip-joint by a Combination of High Amputation and Subperiosteal Enucleation of the Head of the Femur.—The combination of circular amputation of the thigh with a longitudinal incision

DIAGRAMMATIC REPRESENTATION OF DJELITZYN'S OPERATION.



FIG. 107.



FIG. 108.

FIG. 107.—Direction of the sawed surfaces. In addition to the attachment of the rectus muscle those of the sartorius, the gracilis, and the flexors are preserved.

FIG. 108.—Configuration of the stump.

DIAGRAMMATIC REPRESENTATION OF ABRASHANOW'S OPERATION.

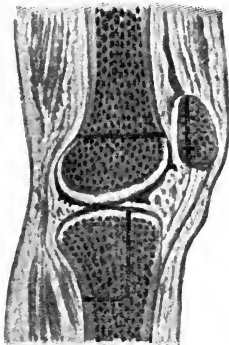


FIG. 109.

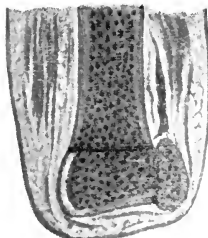


FIG. 110.

FIG. 109.—Direction of the sawed surfaces.
FIG. 110.—Configuration of the stump.

(Esmarch) permits the removal of the femur with a minimum loss of blood. The pelvis of the subject extends beyond the border of the table, and the operator stands as in the performance of amputation. After the application of an Esmarch bandage as close to the trunk as possible a circular incision is made through the skin down to the muscles in the upper third of the thigh. At the point of retraction of the skin the muscles are divided typically in a circular manner down to the bone. The periosteum is likewise incised, and the bone is sawed through. The next step consists in thorough ligation of the vessels in the transverse incision. After the lumen of all the visible vessels is closed by ligation the elastic band is removed. Then a longitudinal incision is made upon the lateral aspect of the thigh, passing over the great trochanter, dividing the soft parts down to the bone, and extending to the level of the wound (Fig. 111). Hooks are introduced into the margins of the incision, and the bone is freed from its attachments. When the separation has been effected throughout a sufficient extent, the operator grasps the bone with his left hand, opens the joint, dislocates the head of the femur, and severs the round ligament, when the central portion of the femur can be removed. The whole operation can be performed without noteworthy loss of blood.

Exarticulation at the Hip-joint by Means of Extirpation.

—Enucleation of the thigh may be most speedily effected through the formation of two musculotegumentary flaps by transfixion. This mode of procedure occupied a prominent position in surgery at a time when rapidity of operation was the primary requirement. At the present day, with the aid of anesthesia, it is considered more important in an operation to reduce the loss of blood to a minimum. Therefore rapid enucleation of the hip with long strokes of the knife is not resorted to, but, according to the method of Verneuil and Rose, the soft parts, after preliminary ligation of the femoral artery, are divided, step by step, with a small scalpel, injured vessels being clamped

or ligated in advance of division. This method of procedure, in which the separation of the tissues is effected

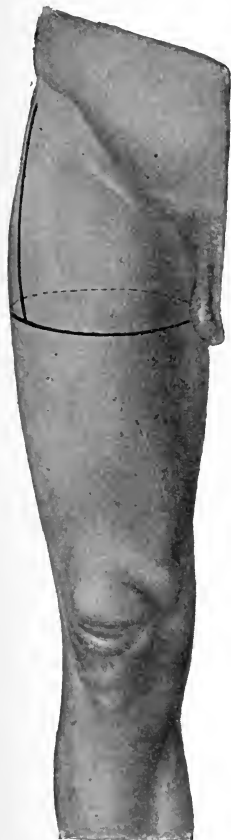


FIG. 111.—Exarticulation at the hip-joint: combination of circular incision and external longitudinal incision.

consecutively according to the principles observed in the enucleation of tumors, is therefore designated extirpation.

The first step in extirpation of the thigh is always ligation of the femoral artery and vein beneath Poupart's

ligament. In the subsequent division of muscles only bleeding branches of the obturator artery, such as the gluteal arteries, will require consideration. The incision most commonly employed is an oval one, whose apex either corresponds with the incision for ligation of the femoral vessels or passes over the trochanter. The base of the incision extends to the junction between the upper and middle thirds of the thigh. The skin is dissected free for a short distance, and the division of the muscles is effected with the scalpel, step by step, and with especial attention to immediate and perfect hemostasis. In this way all the soft parts can gradually be divided down to the bone almost without loss of blood. The last step in the operation consists in opening the hip-joint and enucleating the femur.

Exarticulation at the Hip-joint by Means of Flap-transfixion.—Two tongue-shaped flaps are made that reach to the junction of the middle and upper thirds of the femur, the knife being always introduced from right toward left. If, for instance, the left lower extremity is to be removed, the knife is introduced horizontally upon the outer side of the hip at a point midway between the anterior iliac spine and the apex of the greater trochanter, and passed through the soft parts of the thigh just in front of the capsule of the hip-joint, and brought out in the genito-crural fold. The flap is cut of suitable length and folded back. The operator grasps the thigh with his left hand, places the hip-joint in maximum extension, and opens the joint through an arched incision that penetrates the anterior wall of its capsule. The head of the femur is forced out of the wound and the round ligament is severed. The posterior wall of the capsule is next divided from the interior of the joint; the greater trochanter is exposed by a few incisions, and a musculotegumentary flap is formed from the soft parts of the flexor aspect by an incision from within outward. Care should be taken that the flaps are not too small, and it is further important in making the incision from within outward



FIG. 112.—Enucleations of the fingers: enucleation of the middle finger at the interphalangeal joint; opening of the joint on its dorsal aspect. Formation of a palmar flap by incision from within outward. Upon the thumb: line of incision for removal of the thumb at the carpometacarpal joint by means of an oval incision. Upon the index-finger: flap-incisions.

that the muscles are properly divided, so as not to extend beyond the margins of the flap.¹

Amputations and Exarticulations in the Upper Extremity.—**Exarticulation of the Fingers at the Interphalangeal Joints and at the Metacarpophalangeal Joints.**—In the enucleation of part of a finger the interphalangeal joint is opened transversely upon its dorsal aspect and a flap is formed from the skin upon the flexor aspect by incision from within outward. The operator grasps with the thumb and index-finger of his left hand the finger flexed at the joint at which removal is to be effected. A transverse incision upon the dorsal aspect on the peripheral side of the most marked prominence of the joint opens this. The lateral ligaments of the capsule are divided, and, with the joint opened to its maximum extent, a short tegumentary flap is formed upon the palmar aspect by incision from within outward (Fig. 112). The length of the flap will be governed by the size of the wound to be covered.

A large dorsal and a short palmar tegumentary flap may also be made advantageously, as well as two lateral flaps of equal size or a single lateral tegumentary flap.

The outline of the flap is always first carefully made with a knife; the flap is then dissected free from the subjacent tissues, and the joint is opened from the extensor aspect. The flaps should be so situated that their bases correspond with the line of the articulation at which removal is to be effected.

In making an *oval incision* the operator applies the knife upon the extensor aspect, somewhat to the proximal side of

¹ Hemorrhage can be satisfactorily prevented in amputation of the hip-joint by passing Wyeth's pins and wrapping the elastic band around the limb above them. The pins keep the band from slipping. The outer pin is inserted $1\frac{1}{2}$ inches below and slightly internal to the anterior superior spine of the ilium and emerges back of the great trochanter. The inner pin is entered 1 inch below the level of the crotch and internal to the saphenous opening, and emerges $1\frac{1}{2}$ inches in front of the tuberosity of the ischium. In some cases hemorrhage may be prevented by McBurney's plan. The abdomen is opened and an assistant compresses the common iliac artery.—ED.

the line of the articulation and divides the tissues in the middle line parallel with the longitudinal direction of the finger until the joint has been passed. On the distal side of the joint the incision turns toward the right to run transversely through the flexor fold of the joint and it returns upon the opposite side of the finger, to termi-

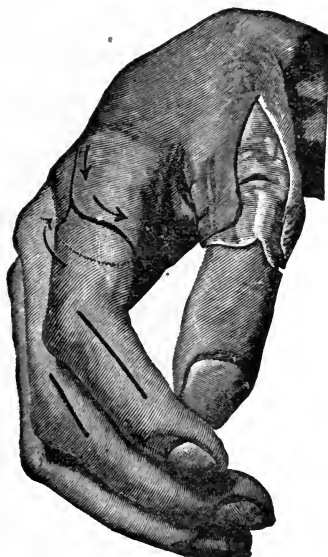


FIG. 113.—Enucleations of the fingers. On the index-finger: line of oval incision for enucleation at the metacarpophalangeal joint. On the thumb: for the same operation the skin is already freed and the joint has been opened on its dorsal aspect. On the middle finger: cutaneous incision for resection of the first interphalangeal joint. Cutaneous incision for resection of the middle phalanx.

nate at its point of origin (Fig. 113). By detaching the tissues on either side of the oval from the subjacent structures the joint is exposed upon its extensor aspect and the removal of the finger can be readily effected. Hemorrhage will be controlled by ligation of the digital arteries, which run on either side near the palmar surface. The

wound left after oval incision is closed in a linear direction.

For *enucleation of the thumb at the carpometacarpal joint* an oval incision is best suited. The apex of the oval is situated upon the extensor aspect of the thumb at a point corresponding to that at which removal is to be

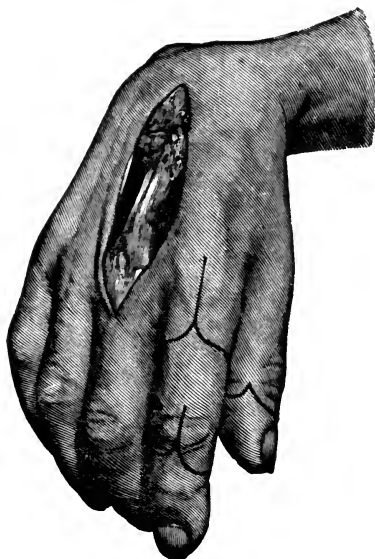


FIG. 114.—Enucleations of the fingers: dorsal, longitudinal incision for excision of a metacarpal bone. Oval incision for enucleation of the index-finger at the metacarpophalangeal joint. Lateral flaps of unequal size for enucleation at the interphalangeal joint. Long dorsal and short palmar flaps for enucleation of the terminal phalanx of the thumb.

effected. At the metacarpophalangeal joint the incision deviates toward the flexor aspect, passing transversely through the flexor fold of this joint and ascends upon the opposite side of the finger to join the longitudinal incision at an acute angle (Fig. 112). The incisions extend throughout down to the bone, from which the soft parts

EXARTICULATION OF THE LITTLE FINGER WITH ITS METACARPAL BONE.

FIG. 115.—First step of the operation. Division of the soft parts between the fourth and fifth metacarpal bones.



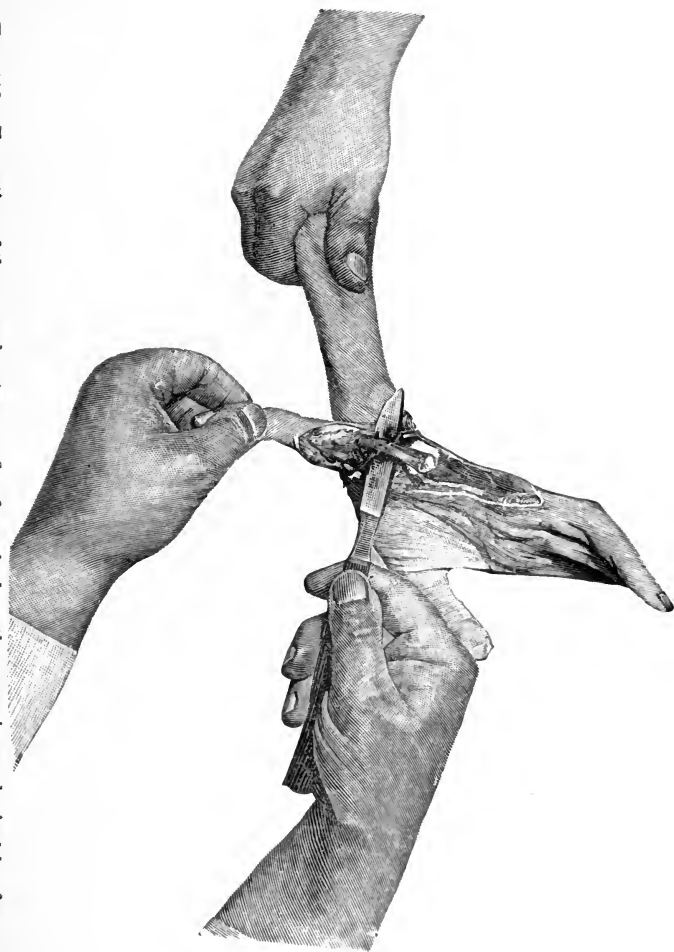
of the thenar eminence are carefully dissected. After the metacarpal bone has been freed, the joint between the trapezium and the base of the metacarpal bone of the thumb is opened from the dorsal aspect and the finger is separated.

Exarticulation of the little finger together with its metacarpal bone by means of a flap from the integument of the ulnar border by the method of Walther. The fourth and fifth fingers are extended and held in a position of maximum abduction. With the dorsum of the hand directed toward the operator, the blade of the knife is introduced at the middle of the commissure between the fourth and fifth fingers (Fig. 115) and passed with sawing movements through the soft parts of the interosseous space between the fourth and fifth metacarpal bones, closer to the latter, to the root of the hand. With the point of the knife, now directed toward the radial border, the ligaments uniting the bases of the two metacarpal bones are first divided, while the little finger is held in a position of marked abduction, after which, by traction in the direction of abduction, the finger can be bent outward in the joint between the unciform bone and the metacarpus. The operator now surrounds the base of the metacarpal bone and forms a flap from the soft parts of the hypothenar eminence by incision from within outward (Fig. 116). Often the flap is cut too short. The operation may also be performed with the aid of an oval incision. The apex of the oval, as well as its longitudinal incision, may be situated either upon the dorsal aspect or upon the ulnar border of the metacarpus.

Amputation of one finger through the metacarpus is effected, like amputation of a toe through the metatarsus, through an oval incision. The apex of the oval is placed upon the dorsal aspect at a point corresponding to the site of amputation. The longitudinal incision passes along the metacarpal bone somewhat beyond the metacarpophalangeal joint, where it encircles the finger through the flexor fold, to ascend on the opposite side and meet the

EXARTICULATION OF THE LITTLE FINGER WITH ITS METACARPAL BONE.

FIG. 116.—Formation of the musculocutaneous flap from the hypothenar eminence by incision from within outward.



longitudinal incision. The muscles are detached from the metacarpal bone, which is divided with the phalangeal or the wire saw. The peripheral extremity of the bone is enucleated and removed (Fig. 67).

Amputation of all four fingers through the metacarpal bones is best effected, like the analogous operation upon



FIG. 117.—Exarticulation of the little finger with its metacarpal bone: wound after completed operation.

the foot, through a short dorsal and a long palmar tegumentary flap. After the flaps have been formed the metacarpus is surrounded with a circular incision, the muscles in the interosseous spaces are divided with a knife, and division of the bones is effected with the saw. The oval incision also may be advantageously employed, the apex of the oval being situated upon one or other border of the hand.

Exarticulations at the Wrist.—The styloid processes of the radius and the ulna constitute the bony landmarks for locating the line of the wrist-joint. The radiocarpal joint, at which the hand is removed, corresponds accurately with a transverse line upon the dorsum of the hand uniting the two styloid processes, when the hand is flexed upon the palm.

EXARTICULATION OF THE HAND.

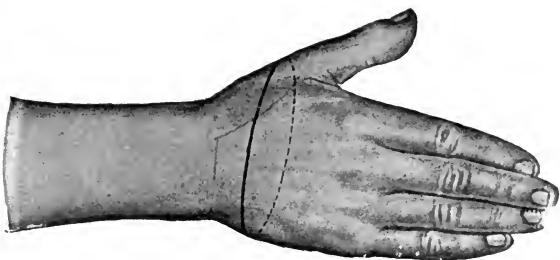


FIG. 118.

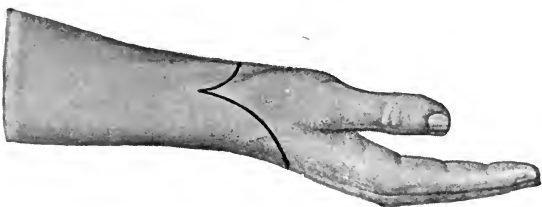


FIG. 119.



FIG. 120.

FIG. 118.—Circular incision in two steps.

FIG. 119.—Dorsal and palmar flaps.

FIG. 120.—Tegumentary flap formed from the thenar eminence.

Enucleation of the Hand by Means of a Circular Incision and the Formation of a Cuff.—The forearm is placed in a position midway between pronation and supination. The operator occupies the same position as in amputation. A



FIG. 121.—Exarticulation of the hand: the dorsal tegumentary flap has been dissected back; opening of the wrist-joint on its extensor aspect.

circular incision is made through the skin two fingers' breadth beyond the apex of the styloid process of the radius (Fig. 118). After a cuff of the tissues has been dissected back the tendons are divided with long strokes of an amputation-knife. The operator stands at the periphery and grasps the member to be removed with his left hand, opening the wrist-joint upon its dorsal aspect, while the hand is held in a position of maximum palmar flexion, the capsule being divided upon the palmar aspect. The radial and ulnar arteries are divided transversely on the palmar aspect of the forearm in their respective sulci.

Enucleation of the Hand by Means of Flap-incisions.—

The apices of the two styloid processes form the extremities of the base of the flap. The dorsal tegumentary flap (Figs. 119 and 121) extends to the middle of the dorsum of the hand. It is dissected free to the line of the joint, which is opened transversely upon its dorsal aspect. The lateral and palmar ligaments are divided, when the exposed flexor tendons of the fingers are made tense by

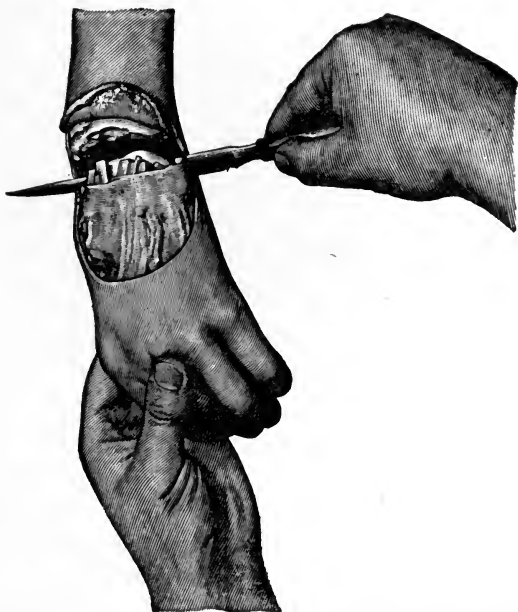


FIG. 122.—Exarticulation of the hand: formation of a short palmar tegumentary flap through incision from within the wound outward.

traction on the hand. The tendons are divided transversely, and a short palmar flap is formed by incision from within the wound outward (Figs. 121 and 122).

It may be necessary after the enucleation of the hand to use the integument of the thenar eminence to cover the wound (Fig. 120). The shape of the tegumentary flap is

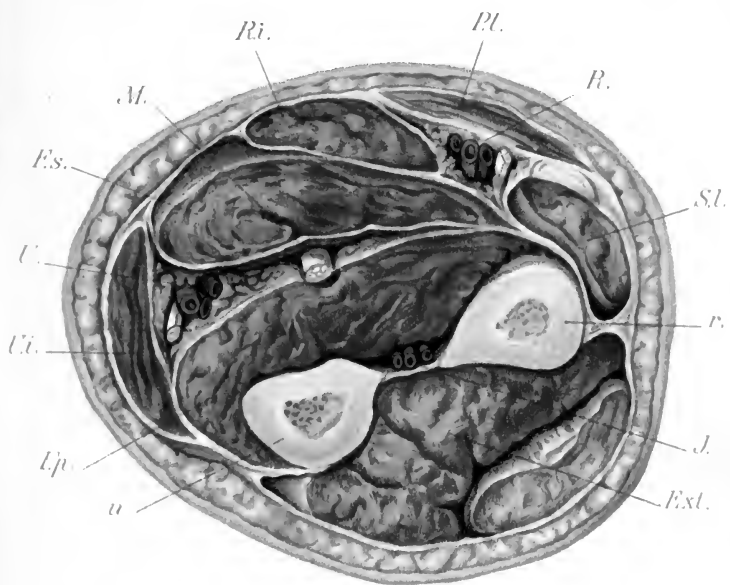
Plate 13.—Transverse Incision through the Middle Third of the Left Forearm.

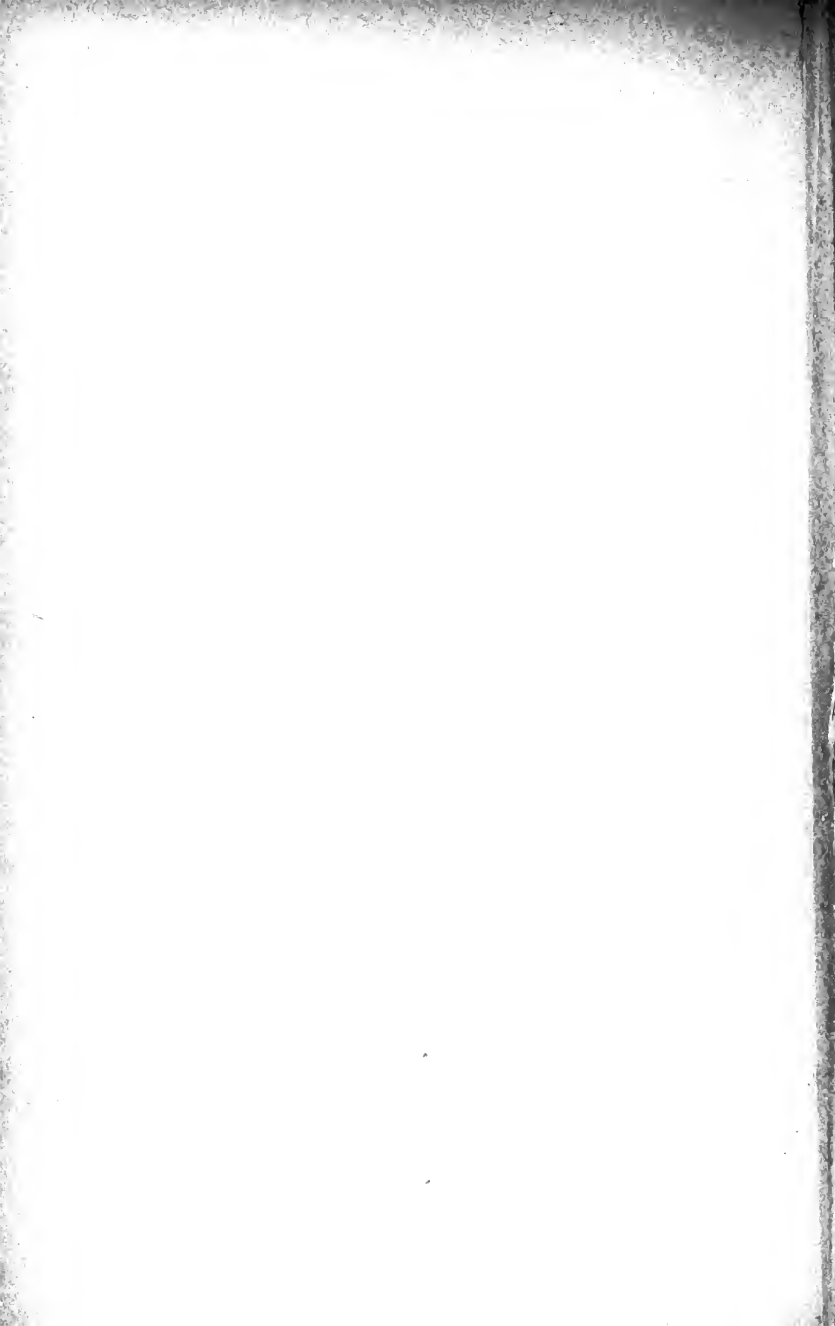
r, radius; *u*, ulna; *F.s.*, flexor digitorum sublimis; *F.p.*, flexor digitorum profundus; *U.i.*, flexor carpi ulnaris; *R.i.*, flexor carpi radialis; *P.l.*, palmaris longus; *S.l.*, supinator longus; *Ext.*, group of extensor muscles; *U*, ulnar artery in a common sheath with the corresponding veins and the ulnar nerve; *R*, radial artery, with the corresponding veins and nerve; *M*, median nerve; *J*, interosseous artery.

outlined by incision, the flap itself dissected free from the subjacent structures, and from its extremities a circular incision is made around the wrist-joint. The division of the tendons and the disarticulation of the hand are effected in the manner described.

Amputation of the Forearm.—By means of a *circular incision*. The arm is held in horizontal abduction from the trunk in a position midway between pronation and supination in such a way that the thumb is directed upward. A circular incision is made, with the formation of a cuff in the usual manner. The muscles are divided, like those of the leg, by a figure-of-eight incision through the interosseous space. In applying the saw the forearm is placed in a position of complete supination, when both bones are divided simultaneously from the palmar aspect. In the transverse section thus exposed (Plate 13) are seen the bones, and they should lie parallel in a position of maximum supination. Between the ulna and the radius is stretched the interosseous ligament, with the interosseous artery and the accompanying vein and nerve on its palmar aspect. The flexors are grouped upon the ulnar and palmar aspect, the extensors upon the radial and dorsal aspect of the stump. In the middle of the stump, between the superficial and deep groups of flexors, is the median nerve, divided transversely. In the connective-tissue interspace in which the nerve is contained lie also upon either side the ulnar and the radial artery.

Of *flap-incisions* suitable for amputation of the forearm the best consist of two musculotegumentary flaps of equal size upon the palmar and dorsal aspects. A single





large palmar musculotegumentary flap may also be advantageously made to cover the wound (Fig. 123).

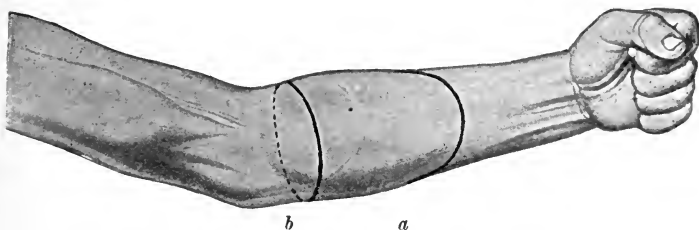


FIG. 123.—*a*, flap-incision for amputation of the forearm; *b*, exarticulation at the elbow-joint through a circular incision.

Enucleation at the Elbow-joint.—The two epicondyles are palpable on either side of the joint, and just below the external condyle the head of the radius can be felt upon pronation and supination of the forearm. The upper border of the radial head marks the situation of the articular line.

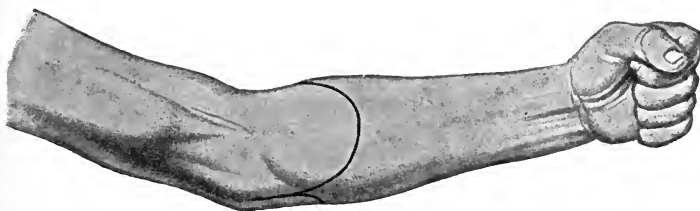


FIG. 124.—Exarticulation at the elbow-joint: flap-incision.

The enucleation is best effected through the formation of broad, well-padded musculotegumentary flaps from the soft tissues of the flexor aspect of the forearm. The operator grasps with his left hand the forearm held in a position of maximum supination. A long, pointed knife is introduced from right to left below the epicondyles at the level of the articular line and passed transversely

Plate 14.—Transverse Incision through the Right Arm at its Middle Third.

B, biceps muscle; *Br. i.*, brachialis anticus; *T*, triceps; *A. b.*, brachial artery in a common sheath with the corresponding vein and the median nerve (*M*); *U*, ulnar nerve; *R*, radial nerve; *M. c.*, musculocutaneous nerve.

through the forearm in close proximity to the anterior surface of the joint. With sawing movements of the knife a flap is formed, which extends to the junction of the middle and upper thirds of the forearm (Fig. 124). The flap is reflected upward and with a scalpel the anterior portion of the capsule of the elbow-joint is divided

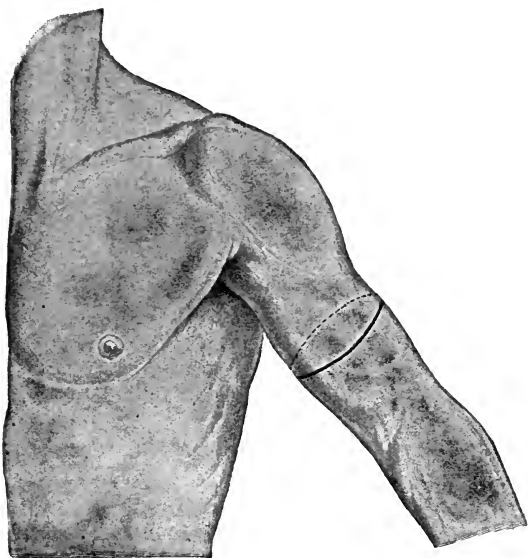
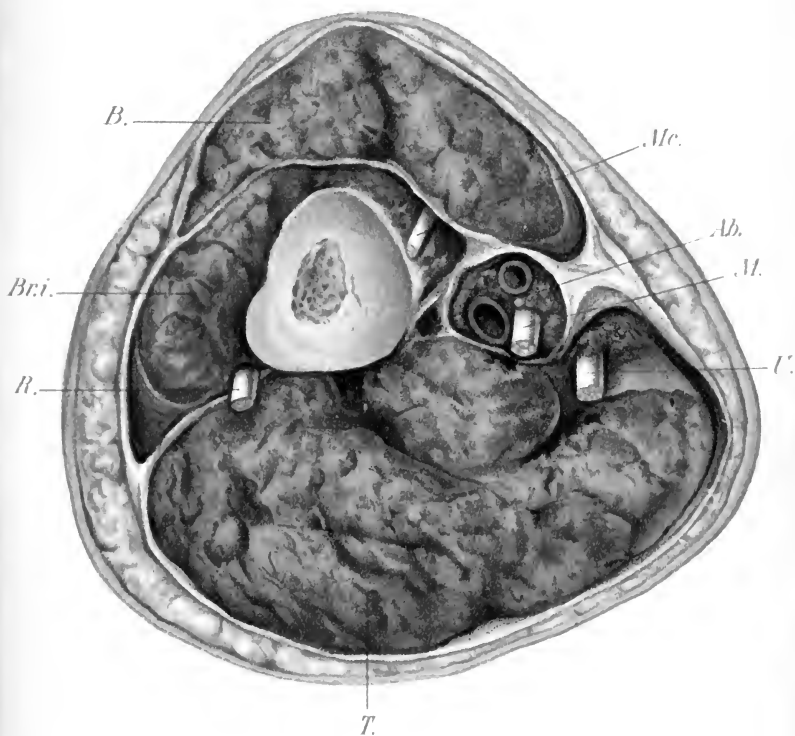


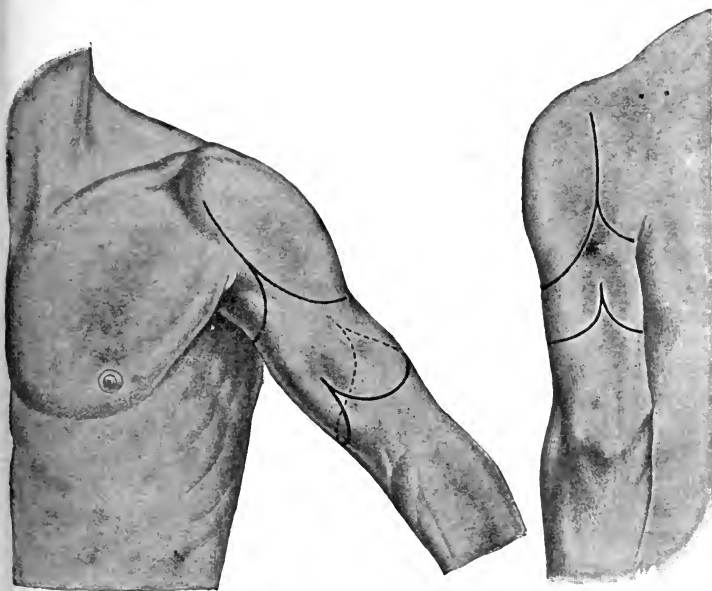
FIG. 125.—Amputation of the arm: circular incision.

transversely, so that the trochlea and the radial head of the humerus are exposed. With the elbow-joint over-extended the operator divides the external and then the



internal lateral ligament. Continuing the over-extension the olecranon is brought into the wound. The attachment of the triceps muscle is dissected close to the bone and a short tegumentary flap is formed upon the dorsal aspect by incision from within the wound outward. Upon the flexor aspect the two branches of the brachial artery are to be ligated.

The circular incision for exarticulation at the elbow-joint is made about three or four fingers' breadth below the line of the articulation, and a cuff is dissected in the usual manner to the level of this line and reflected up-



FIGS. 126 and 127.—Flap-incisions for amputation and enucleation of the arm.

ward. The joint is opened, and the exarticulation is effected in the manner described.

Amputation of the Arm.—A circular incision may be

employed, as well as the formation of two musculotegumentary flaps.

The *circular incision* (Fig. 125) is made either in the customary manner in two steps, with the formation of a cuff, or with a single stroke of the knife after the soft parts have been vigorously retracted. In the stump of the amputation (Plate 14) the brachial artery is ligated in the interval between the biceps and triceps muscles. The radial nerve, which passes through the triceps muscle in the outer portion of the stump, is accompanied by an artery.

Of *flap-incisions*, the most useful consists in the formation of an internal and an external musculotegumentary flap. The flaps meet anteriorly upon the biceps muscle and posteriorly over the middle of the triceps. The internal flap contains the brachial artery (Figs. 126 and 127).

Exarticulation of the Humerus.—In operations upon the shoulder, as in operations about the hip-joint, the application of the Esmarch bandage to control hemorrhage is attended with considerable difficulty, and the methods employed are modified accordingly. The artery is either ligated in advance, or it is divided at the last stage of the operation while digital compression is made.¹

Exarticulation by Means of a Deltoid Musculotegumentary Flap.—The trunk of the subject is elevated and the operator outlines a flap in the deltoid region with a U-shaped incision whose upper extremities correspond with the acromion and the apex of the coracoid process, and which extends as low as the insertion of the deltoid muscle (Figs. 126 and 127). After the tissues are divided down to the muscles the flap retracts somewhat. The musculotegumentary flap is dissected from the bone by long strokes of the knife. By dissection of the flap the shoulder-joint is exposed. The operator grasps the arm

¹ Wyeth's pins may be used as in the hip. The anterior pin enters at the middle of the lower margin of the anterior axillary fold and emerges 1 inch internal to the tip of the olecranon. The posterior pin enters at the middle of the lower margin of the posterior axillary fold and emerges more posteriorly than the first pin and 1 inch internal to the tip of the acromion.—ED.

with his left hand, and divides the capsule of the joint by applying the knife vertically upon the head of the humerus and passing it in an arched direction over the most prominent convexity of the bone (Fig. 130). The head of the humerus is forced out of the wound, the attachment of the posterior wall of the capsule separated from the bone, and the surgical neck of the humerus, as well as the upper

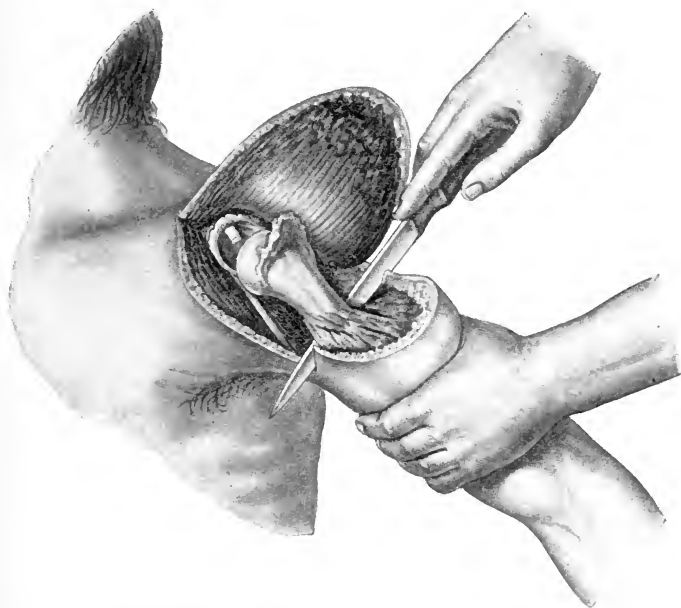


FIG. 128.—Exarticulation of the humerus: formation of an axillary musculotegumentary flap by incision from within the wound outward.

extremity of the shaft of the bone, is freed from the soft tissues. In this way a bridge is formed of the soft tissues of the axilla in which the vessels are contained. While an assistant grasps this bridge between the thumb and index-finger of each hand in such a way as to compress the artery, a flap is cut from the soft tissues of the axilla at a level corresponding with the attachment of the pecto-

ralis major muscle to the humerus from within the wound outward (Fig. 128). While the digital compression is continued, the axillary artery is ligated. At the inner side of the deltoid flap branches of the posterior circumflex artery are to be secured by ligature.

Exarticulation by Means of a Circular Incision in Conjunction with a Longitudinal Incision.—The arm is sur-

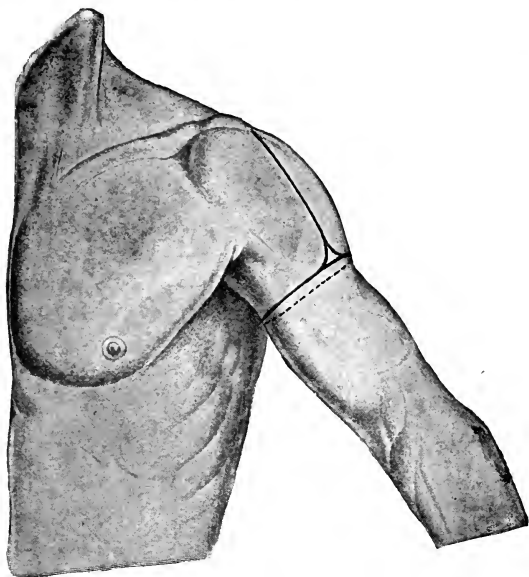


FIG. 129.—Exarticulation of the humerus by a combination of circular and longitudinal incisions.

rounded at the highest point possible by an Esmarch tube. The patient occupies a similar position to that for amputation of the arm. A circular incision is made through the skin below the attachment of the deltoid muscle, and at the point of retraction the muscles are divided circularly and the bone is sawed through. Hemorrhage from the divided surface is controlled, and the



FIG. 130.—Exarticulation of the humerus: division of the articular capsule.

elastic tube is removed. The body of the subject is elevated, and a longitudinal incision is made from the coraco-acromial furrow down to the wound (Fig. 129). The incision passes through the deltoid muscle and exposes the capsule of the joint. The margins of the incision are separated by tenacula, and the muscle is detached from the shaft of the bone. The joint is opened in the manner described, and the bone is separated carefully from its attachments.

An *oval incision* may also be employed in operations at the shoulder-joint in such a way that the longitudinal portion of the incision is made from a point midway between the coracoid and acromion processes to the insertion of the deltoid, through the muscle down to the joint, while the transverse incision through the flexor aspect passes only through the skin. The margins of the longitudinal incision are separated by tenacula, the joint is opened, and the head and the neck of the humerus are exposed and forced out of the wound. While the artery is compressed in the wound the operator cuts the base of the oval toward the axillary cavity in the incision previously outlined.

Exarticulation of the Arm together with the Shoulder-girdle.¹—This important operation, which may become necessary in the removal of tumors, is most safely undertaken according to the method of extirpation at the hip proposed by Rose, step by step with the scalpel, with constant consideration for the control of hemorrhage. The skin is incised in the shape of an oval with an elongated apex (Berger), which is situated upon the clavicle near its sternal extremity. The incision passes along the clavicle, from which it deviates in front over the pectoral muscles, almost vertically downward to the axillary cavity, through which it passes transversely, to ascend upon the dorsal aspect of the shoulder to the acromial extremity of the clavicle, where it joins the longitudinal incision. Then the clavicle is exposed through the longitudinal incision, is carefully freed at

¹ Amputation of the entire upper extremity.—ED.

all points from its periosteum, and is divided at its middle third with the wire saw. If the external fragment of bone is strongly raised with a tenaculum, access to the large vessels and to the nerve-plexus will become free. The subclavian artery and vein are isolated and ligated upon the first rib. In order to render the operation bloodless it will be necessary to ligate in addition the transverse scapular and the superficial cervical arteries (in front of the anterior scalene muscle), and on the distal side of the posterior scalene space, therefore behind the anterior scalene muscle, also the transverse artery of the neck, which disappears among the nerve-trunks. The nerves of the plexus are then divided individually. Through the anterior incision, division of the two pectoral muscles is effected separately, and, after the axillary incision has been deepened, the latissimus dorsi is divided. The muscles attached to the acromial extremity of the clavicle, to the spine, and to the upper and inner borders of the scapula (trapezius, serratus magnus, rhomboid, omohyoid, and elevator of the scapula) must yet be divided, and this is best effected with forcible elevation and rotation outward of the arm together with the shoulder. The cutaneous wound is sutured in the longitudinal axis of the oval incision.

III. Resections at the Joints of the Extremities.

By resection of a joint is understood the systematic removal of its constituent parts, with conservation of contiguous structures. In the presence of tuberculous disease, as well as of severe injuries about the large joints, resection promised to be a conservative substitute for amputation. It can thus be understood that this mode of procedure was expected to prove a great advance in surgery in times of both war and peace. The methods of operation were so selected that compensation for the loss of the parts removed could reasonably be hoped for. With this thought Langenbeck devised operations for all

the joints in which the capsule was permitted to retain its connection with the periosteum, of whose osteoplastic activity experimental proof had been furnished (subperiosteal resection). Langenbeck's incisions are still largely used in the performance of resections. The introduction of asepsis, as well as a more precise knowledge concerning the nature and the extension of the tuberculous process in joints, has changed our views with regard to these operations fundamentally. Antisepsis renders possible successful conservative treatment of injuries to joints, even without resection, for which previously amputation appeared indicated. The nature of the tuberculous process and the extent of its distribution in the joints, further, make it undesirable to adopt the routine plan of procedure in every case of removing the bones entering into the constitution of the joint, while the capsule as such is permitted to remain. Resection of tuberculous joints is at the present day no more regarded as a typical procedure to be employed in every case than, for instance, is the extirpation of tumors; nevertheless, opening of the joints in a typical manner is practised upon the cadaver, as by this means the surgeon familiarizes himself with methods by which it is possible to open the joints with great care, and which render accessible the parts that enter into the formation of the joint, as well as the synovial surfaces of the capsule throughout their entire extent. Thus, in a certain sense, the preliminary operation is performed, with which clinically, in accordance with the requirements of the individual case, the actual operation, the removal of parts the seat of tuberculous disease, is conjoined. The capsule of the joint is widely opened (*arthrotomy*), the synovial sac is exposed throughout its whole extent, and in accordance with the extent of the morbid process extirpation of the synovial membrane (*synovial arthrectomy*). Curetting of foci in the bone if necessary after exposure by means of the gouge or the chisel and mallet, or resection of the articular extremities (*osseous arthrectomy*), is undertaken. When the disease is

advanced, the bones are sawed through. In some joints—*e. g.*, the hip-joint—division of one of the bones entering into the articulation with a saw must be undertaken in order that the joint may be made accessible throughout its whole extent for the effectuation of the necessary operative measures.

Indications :

1. *Injuries*, complicated destructive lesions of the constituents of the joint, especially if large portions of bone are completely severed from their attachments.

2. *Tuberculosis* of joints, if conservative measures (rest and fixation of the joint, treatment with iodoform, blood-stasis, minor local measures) have failed.

3. *Acute inflammatory processes* in bones, osteomyelitis with epiphyseal separation and suppuration of the affected joint.

4. *Deformities* of the joints. Orthopedic resections for the correction of severe, otherwise irreparable alterations in conformation (contractures, ankylosis).

5. *Luxations*, if irreducible and attended with marked limitation of function.

6. *Flail-joints* which it is desired to ankylose artificially (arthrodesis).

7. Finally, *tumors of the articular extremities* may furnish the indication for resection.

The incisions are made with short, strong knives, through the soft parts, down to the bone. After division of the capsule this, together with the periosteum, is separated from its attachment to the bone and the latter is divided with the saw. The incisions through the soft parts are so arranged that transverse division, especially of muscles, tendons, large nerves and vessels, is so far as possible avoided. Langenbeck's incisions for resection correspond mostly with the longitudinal axis of the extremities. The articular capsule is opened as freely as possible in the direction of the cutaneous incision. The margins of the wound in the capsule being separated widely by means of tenacula, the operator begins, by

means of a series of closely approximated incisions with a resection-knife, which is always applied vertically upon the bone, to separate the attachments of the capsule together with the periosteum. The bones are forced out of the wound and divided by means of the arched saw, the metacarpal saw, the wire saw, or the chain saw. The plane of the sawed surface varies with the individual joints.

For the correction of angular contractures wedge-shaped excision of bones is necessary. In place of this, curved resection (Helferich) may be employed, and the resulting shortening will be less.

After resection of the bone has been effected the sawed surfaces are brought in apposition and fixed by means of nails or clamps, or even without these in a bandage. The division of the capsule, of the muscles, and of the skin is closed by sutures. By the introduction of drainage-tubes or of capillary drains escape of wound fluids is provided for.

Resections of the Joints of the Upper Extremity.—**Resection of the Shoulder-joint by the Method of Langenbeck.**—The patient is placed upon the operating-table in a sitting posture in such a manner that the shoulder projects somewhat beyond the border of the table. The operator stands upon the side of the trunk, with his face directed toward the shoulder. He grasps the upper arm at its middle with the left hand and with the arm hanging naturally he enters the resection-knife held almost vertically into the coraco-acromial trigone (Fig. 12). The incision is made in the longitudinal axis of the arm through the deltoid muscle, almost to its insertion into the humerus, and down to the joint capsule (Fig. 131). The upper extremity of the incision divides the tense band between the acromion and coracoid processes. After the margins of the wound have been widely separated by hooks the lateral wall of the capsule is exposed. With slight rotation outward of the arm the tuberosities of the humerus and the bicipital groove are brought to

the level of the wound. The capsule is incised and divided in a line corresponding to the bicipital groove upward to the glenoid cavity, and downward to the surgical neck of the humerus. The tendon of the biceps thus exposed is raised from its bed by means of blunt hooks and displaced inward over the head of the humerus. Through the incision in the capsule which exposes the tendon of the biceps the separation of the capsule from the bone

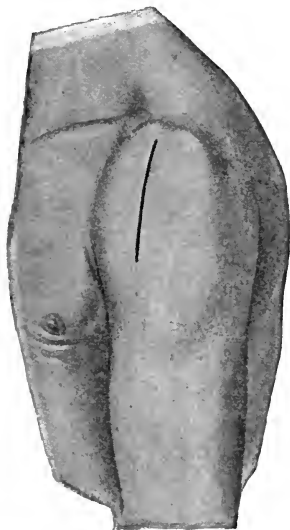


FIG. 131.—Resection of the shoulder: longitudinal incision.

is undertaken. With the aid of a hook introduced into the slit in the capsule the latter is elevated and dissected free from the humerus close to the bone. The operator progresses step by step, while the arm is rotated toward the knife. After the capsule has been divided throughout half of its circumference the remainder is similarly detached from the bone, the operator proceeding from the original slit in the capsule in the opposite direction. To-

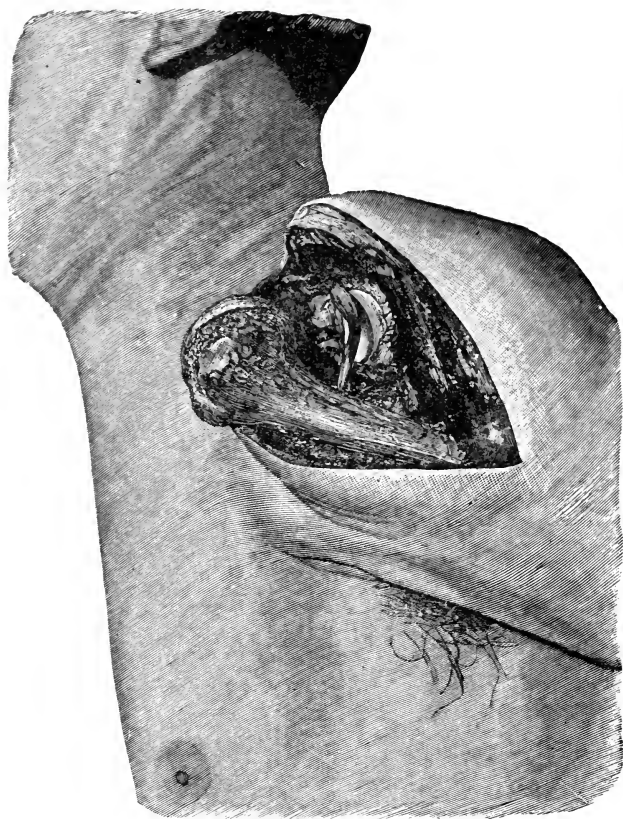


FIG. 132.—Resection of the shoulder: the head of the humerus is lifted out of the wound for division with the saw after subperiosteal detachment.

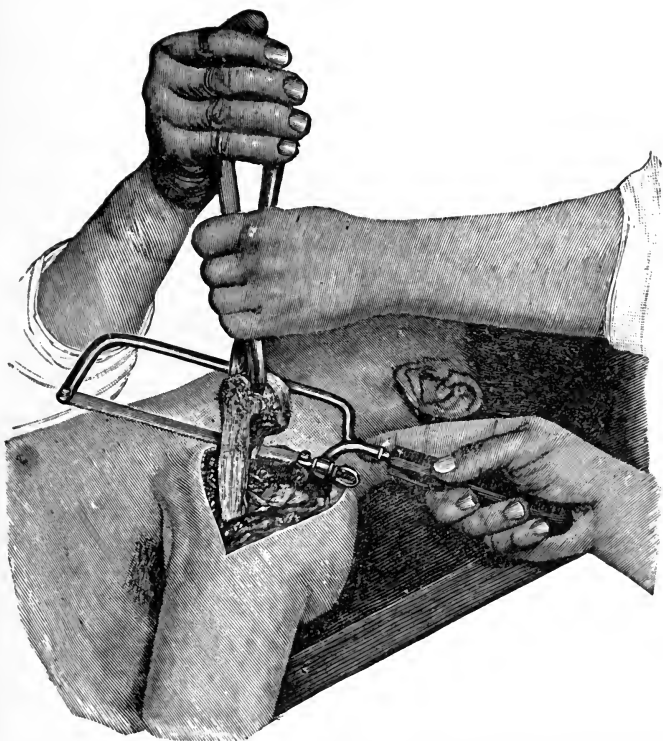


FIG. 133.—Resection of the shoulder: division of the head of the humerus with the saw; the head of the bone is fixed by means of Langenbeck's forceps.

gether with the capsule, the attachments of the shoulder-muscles that enter into its formation (supraspinatus, infraspinatus, subscapularis) are separated from the bone. When the head of the bone has been thus freed, it is lifted out of the wound (Fig. 132), and divided at the level of the surgical neck of the humerus either by means of the chain-saw, or, after fixation with Langenbeck's forceps, with the arched saw (Fig. 133). The tendon of the biceps muscle is by this procedure preserved intact. After removal of the head of the humerus the glenoid cavity, as well as the whole interior of the capsule, is sufficiently exposed for whatever further operative procedures may be necessary. Vessels of considerable size are not injured in performing resection of the shoulder through a longitudinal incision.

Resection of the Shoulder-joint from Behind (Kocher).—This method permits of freer inspection of the joint, with preservation of the deltoid muscle and the corresponding nerves. The cutaneous incision begins at the acromion process and passes to the middle of the spine of the scapula, whence it continues downward in the form of an arch to two fingers' breadth beyond the posterior axillary fold. The upper incision opens the acromioclavicular articulation and separates in its further course the attachment of the trapezius muscle to the upper border of the spine. The descending limb of the incision exposes the posterior border of the deltoid, and this muscle is separated from the subjacent structures, as also are the supraspinatus and the infraspinatus at the neck of the scapula until the lateral border of the crest can be grasped at the point where it arises from the scapula. The exposed bone is divided obliquely with the chisel (avoiding the suprascapular nerve), and, together with the deltoid muscle, is reflected forward over the humerus. The posterior aspect of the articular capsule is exposed, with the attachments of the supraspinatus, the infraspinatus, and the lesser round muscle. With the arm rotated outward, a longitudinal incision is made along the posterior margin

of the bicipital groove, through the capsule down to the bone. Through this the tendon of the biceps to its insertion into the margin of the glenoid cavity is exposed. From this incision the supraspinatus and the infraspinatus, together with the capsule and the periosteum, are detached from the greater tuberosity, and if necessary also the subscapular muscle in front is detached in the same way from the lesser tuberosity of the humerus. When the head of the bone is dissected free, a clear view of the glenoid cavity will be secured.

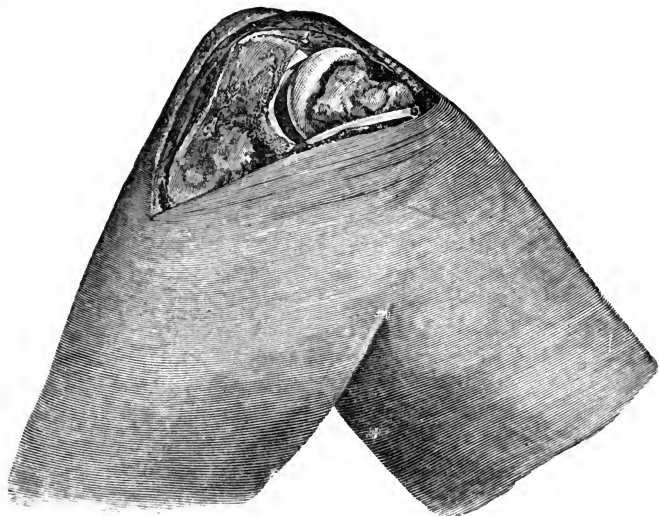


FIG. 134.—Resection of the elbow-joint: exposure of the elbow-joint on its inner aspect; the olecranon and the inner extremity of the trochlea come into view; the ulnar nerve has slipped from the inner epicondyle after retraction of the margin of the wound.

Resection of the Elbow-joint through a Dorsal Longitudinal Incision.—The arm is flexed at a right angle at the elbow-joint and thrown over the thorax in such a manner that the extensor aspect of the joint, turned upward, is rendered accessible. The operator stands upon

the side of the thorax that corresponds with the healthy member. The incision is made upon the dorsal aspect of the joint, through the lower extremity of the triceps muscle over the olecranon (Fig. 135). Langenbeck makes this incision rather nearer the inner border; Chassaignac makes it upon the outer border of the olecranon, although it may also be made satisfactorily in the middle line (Park). The incision passes through the triceps muscle down to the bone. While the lips of the wound in the muscle are energetically separated by means of hooks, the posterior wall of the capsule of the elbow-joint bulges into view and is divided in the direction of the cutaneous incision. With strokes of the knife directed vertically toward the bone the tendon of the triceps is detached from the olecranon close to the bone. At the same time the muscles inserted upon the dorsal aspect of the upper extremity of the ulna are detached in conjunction with the periosteum. Upon the outer side the radial head of the humerus and the head of the radius come into view, and the strong fibrous lateral ligament is to be freed close to the bone. On the inner side the detachment of the tendon of the triceps from the olecranon is begun. At the same time the muscles are dissected free also from the upper extremity of the ulna. While the free margin of the wound is drawn, through marked flexion at the elbow-joint, inward and toward the flexor aspect, the inner epicondyle of the humerus appears within the field of operation. The muscles attached to this process (pronator radii teres and flexors of the hand and of the fingers) should also be detached close to the bone. In order not to injure the ulnar nerve dislocated from its place on the trochlea by the side of the inner epicondyle, the detachment of the muscles from the inner epicondyle is carried out in such a manner that the semicircular incisions are made to pass close together from the apex of the epicondyle to the base of this bone (Fig. 134). In this manner the ulnar nerve is kept entirely out of reach of the knife. By further dissection the inner margin of the trochlea and the sigmoid

MODE OF MAKING INCISIONS FOR RESECTION OF ELBOW-JOINT.

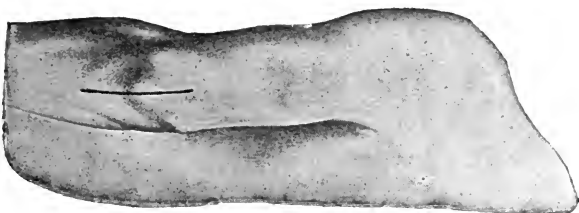


FIG. 135.



FIG. 136.

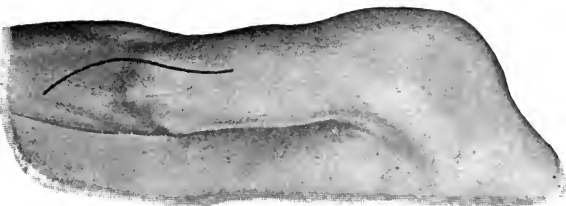


FIG. 137.

FIG. 135.—Longitudinal incision by the method of Laugenbeck.
FIG. 136.—Bayonet-shaped incision by the method of Ollier.
FIG. 137.—Radial angular incision by the method of Kocher.

Plate 15.—Resection of the Elbow-joint by the Method of Kocher (Right Arm).

The joint is opened from its outer aspect. The capsule and the periosteum are detached from the external epicondyle (*C*), from the head of the radius (*R*), from the upper end of the ulna (*U*). In the background the interior of the articular capsule (*K*) with its synovial villi is visible.

cavity of the ulna are freed. When the separation of the capsule has extended beyond the attachments of the lateral ligaments the articular extremity of the humerus, as well as those of the bones of the forearm, can be forced out of the wound (Fig. 138). The bones are grasped

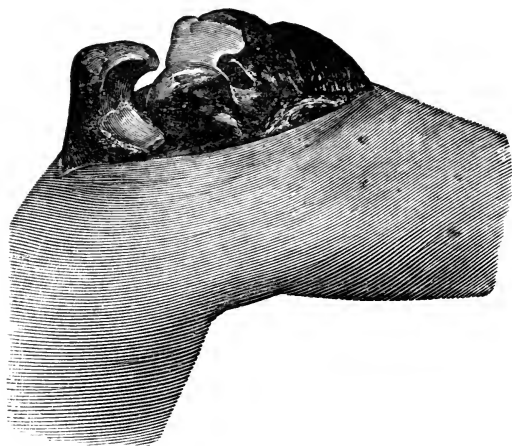
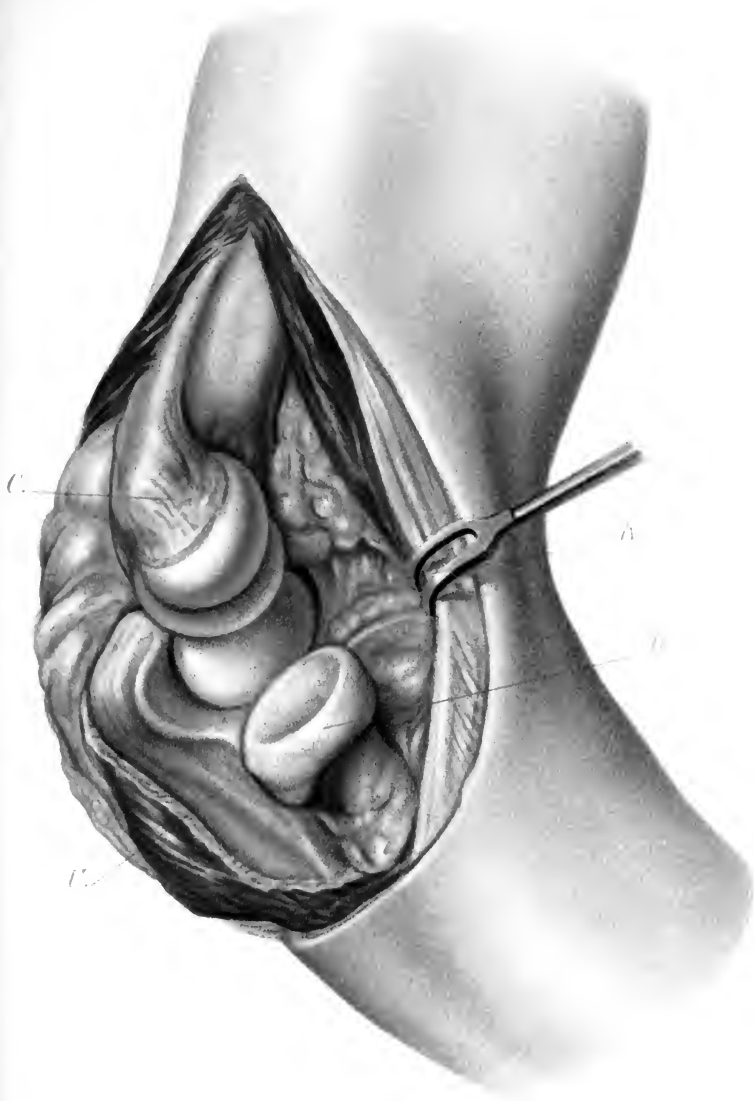
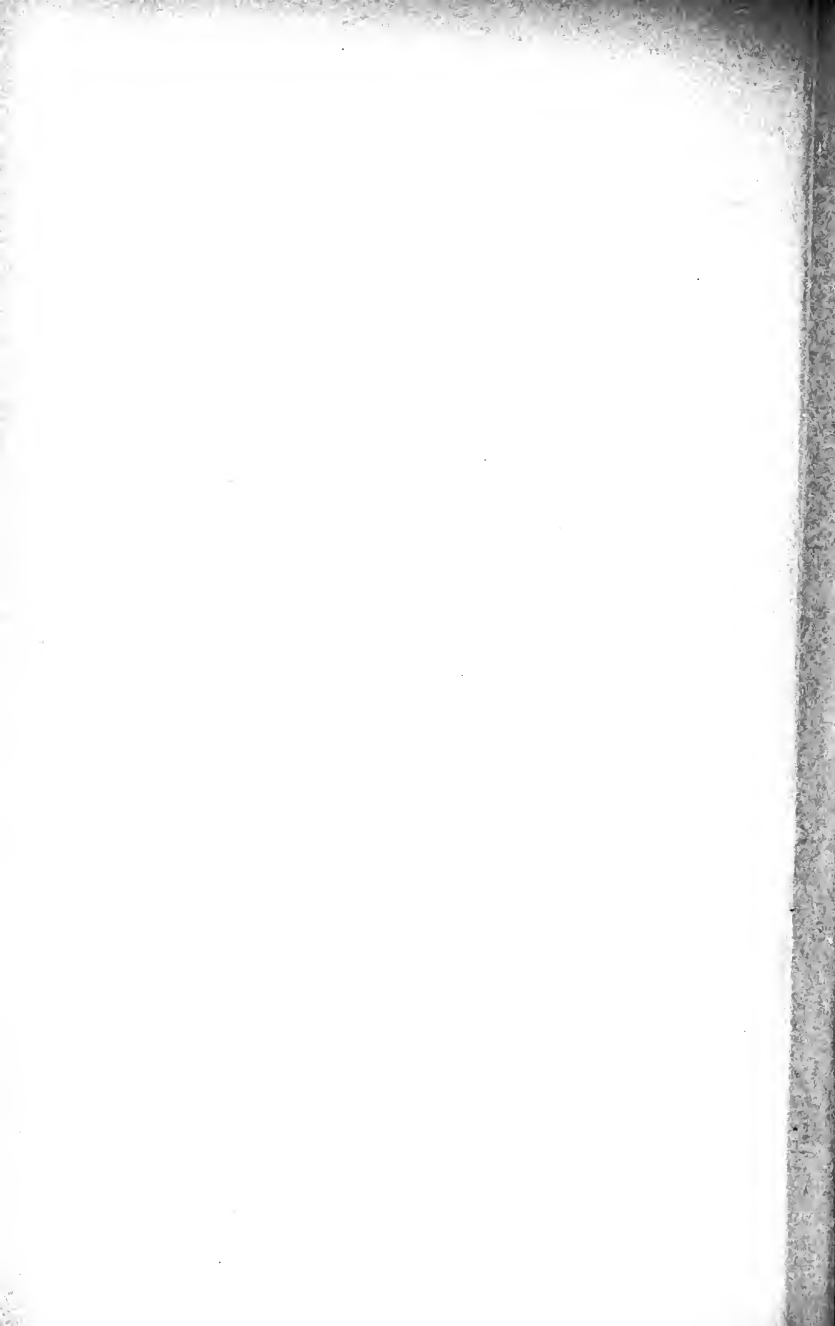


FIG. 138.—Resection of the elbow-joint: the constituent parts of the elbow-joint are completely exposed and pushed out of the longitudinal incision.

with Langenbeck's forceps and sawed through, the humerus above the trochlea, the bones of the forearm upon the distal side of the head of the radius and the coronoid process.

In describing the steps of the operation its performance





upon the dead subject has been kept in view. In actual clinical experience the mode of procedure is subjected to certain modifications. Thus, the disarticulation and the isolated division of the bones with the saw may be omitted in the treatment of cases of ankylosis of the joint.

Resection of the Elbow-joint by the Method of Kocher.—The elbow-joint is flexed at an obtuse angle. The incision (angular incision) begins at the outer side of the lower extremity of the humerus, from 3 to 5 cm. above the articular line, and passes parallel with the axis of the arm to the head of the radius, and thence in a slight curve along the outer border of the anconeus muscle to the margin of the ulna, from 4 to 6 cm. below the tip of the olecranon (Fig. 137). The incision penetrates between the long supinator and the radial extensors on the one hand, and the border of the triceps on the other hand, down to the humerus, and lower down between the ulnar extensor of the carpus, and the anconeus down to the ulna, and divides the articular capsule. Through the fissure thus made the attachment of the triceps and the anconeus, together with the capsule and the periosteum, are detached from the ulna. The flap thus formed is reflected over the olecranon toward the ulna; the dissection at the external condyle of the humerus and at the head of the radius is completed until the constituents of the joint can be reflected and generous access to the joint is afforded (Plate 15). Kocher saws through the olecranon in an arched manner.

Other Varieties of Resection of the Elbow-joint.—A longitudinal incision is made on either side of the joint (Vogt, Hueter); or an H-shaped incision is made (Moreau), the transverse portion dividing the tendon of the triceps above its attachment; or a transverse incision is made upon the extensor aspect of the joint over the olecranon process, with temporary transverse division of the olecranon with a saw (Szymanowsky, Bruns); or a bayonet-incision is made (Ollier) (Fig. 136).

Resection of the Wrist-joint.—*Dorsoradial Incision by Langenbeck's Method.*—A cutaneous incision is made upon the dorsal aspect from the middle of the ulnar border of the metacarpal bone of the index-finger to the middle of

the lower extremity of the radius (Fig. 139). The incision passes between the tendons of the extensor communis digitorum and the extensor hallucis longus, and divides the dorsal transverse ligament of the carpus. The attachments of the radial extensor muscles are separated from the base of the metacarpal bones and the radiocarpal joint is opened. By means of a knife or a sharp raspatory the



FIG. 139.—Resection of the wrist-joint: Langenbeck's dorsoradial incision.

capsule of the joint is freed from the dorsal aspect of the bones at the root of the hand, the individual small joints opened, and the bones extirpated singly (Fig. 140).

The *dorso-ulnar incision* (Lister) for resection of the wrist-joint is made, with the hand in slight radial flexion, from the middle of the fifth metacarpal bone to the middle of the wrist-joint, beyond the radial epiphysis. The

dorsal transverse ligament of the carpus is divided, when, by the side of the extensor tendons of the finger retracted toward the radial aspect, access to the joint is gained. At the base of the fifth metacarpal bone the tendon of the extensor carpi ulnaris must be detached from the bone. Now the attachment of the capsule may be freed, beginning at the ulna, when the carpal bones are exposed and removed individually. If it be necessary to remove also the epiphysis of the radius, this is forced out of the wound,



FIG. 140.—Resection of the wrist-joint: dorsoradial incision; the extensor tendons are displaced to one side; the lower extremity of the radius and the two rows of carpal bones are exposed to view.

grasped by its styloid process with Langenbeck's forceps, and divided transversely with the saw. The procedure is simplified if, according to the method of Kocher, in order to increase the accessibility to the joints, the hand is completely luxated in a radio-palmar direction, as a result of which the extensor tendons are displaced toward the radius. In this position the enucleation of the carpal bones, and the division with the saw of the extremities of the bones of the forearm, will be unattended with difficulty.

Resection of the Fingers.—*Resection at the metacarpophalangeal joints* of the thumb, the index and the little fingers, as well as at the interphalangeal joints, is effected through a lateral incision, thus completely protecting the extensor as well as the flexor tendons. The incision opens the joint laterally. The capsular attachments are separated upon the dorsal and palmar aspects of the bone, and the articular extremities of the bones are forced out of the wound and divided with the saw. After removal of the bones the synovial surface of the joint is completely exposed. The metacarpophalangeal joint of the thumb becomes accessible only after separation of the muscles of the thenar eminence. The metacarpophalangeal joints of the middle and ring-fingers are exposed by means of dorsal longitudinal incisions, the opening of the joint and the removal of the articular extremities being effected in the typical manner. Resection of an entire metacarpal bone is effected through a dorsal longitudinal incision extending from the base to the head of the bone, which is exposed by subperiosteal detachment of the interosseous muscles on either side, and is raised from its surroundings after the joint at its base and that at its head have been opened (Fig. 114). The resection of entire phalanges is effected through lateral longitudinal incisions.

Resection of the Joints of the Lower Extremities.—**Resection of the Hip-joint.**—*External Longitudinal Incision by the Method of Langenbeck.*—The patient to be operated upon lies upon the unaffected side. The diseased extremity is flexed at an obtuse angle and held in a position of slight adduction. The incision passes from the posterior superior iliac spine parallel with the long axis of the extremity over the greater trochanter, and continues at once through the gluteal muscles down to the iliac bone and the articular capsule. The tendons inserted into the trochanter are detached close to the bone, the capsule is divided, and the articular cartilage at the margin of the acetabulum incised. The knife is introduced into the joint, and the round ligament divided while the member

is held in a position of forced flexion, adduction, and internal rotation. In this way the head of the femur is made to lie upon the iliac bone. The chain-saw is passed around the neck of the femur, and the head of the bone is thus divided.

Kocher's angular incision, an improvement upon Langenbeck's method, begins at the base of the posterior surface of the greater trochanter, ascends to the apex of the trochanter, whence it passes at an angle obliquely upward in the direction of the fibers of the gluteus maximus. The fascia of this muscle is divided. The upper limb of the incision divides the gluteus maximus in its longitudinal direction. Beneath this an entrance is gained in the same direction to the space between the gluteus medius and minimus on the one hand, and the pyriformis on the other hand. When the pyriformis is retracted downward, the posterior aspect of the capsule will be reached. The pyriformis tendon is detached from the trochanter, and, with the internal obturator and the gemelli, is retracted inward, while the gluteus medius and minimus, likewise detached close to the bone, are dislocated outward. The exposed capsule can now be freed at its attachments, and where this appears necessary it can be removed in connection with the synovial membrane, or the capsule is opened, the round ligament divided, and the head of the femur luxated and removed.

External Arched Incision by the Method of Velpeau.—The patient occupies the same position as in Langenbeck's operation. The resection-knife is introduced at a point midway between the anterior superior iliac spine and the apex of the great trochanter, and is carried vertically down to the concavity of the ilium. The incision surrounds the anterior three-fourths of the periphery of the trochanter, and at all points extends down to the bone (Fig. 141). Care should be taken that the gluteal muscles are divided in a vertical direction. If the margins of the wound are separated at its depth, the fibrous capsule of the joint becomes visible. Over the highest prominence

of the head of the femur the capsule is divided by an arched incision corresponding with the cutaneous incision. The articular cartilage is incised, and after division of the ligamentum teres the head of the femur is luxated upon the ilium and removed. If the removal of the head is to be effected at a point between the trochanters, or on the shaft of the femur, the tendons inserted into the trochanters must be detached from the bone with the knife. After the head of the bone has been sawed off, the aceta-

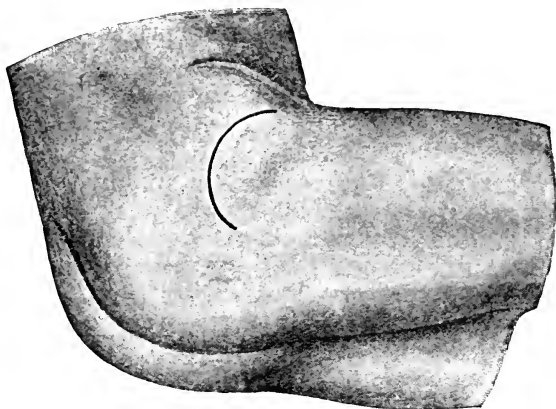


FIG. 141.—Resection of the hip : external arched incision by the method of Velpeau.

bulum is exposed for such further surgical interference as may be necessary. The extremity is placed in an extended position, and a drainage-tube is passed into the depths of the acetabulum.

König has modified Langenbeck's operation by removing with a chisel the head of the femur *in situ* before it is luxated. Further, the attachments of the muscles to the greater trochanter are not separated from the bone, but are removed, in conjunction with the cortical structure of the trochanter, upon its anterior and posterior sides, with chisel and mallet.

The anterior longitudinal incision of Lücke and Schede passes downward from the anterior superior iliac spine. The joint is entered to the outer side of the crural nerve.

The anterior transverse incision of Roser is attended with the disadvantage that the fibers of numerous muscles are divided transversely.

Resection of the Knee-joint through an Anterior Transverse Incision.—The operator grasps the leg of the ex-

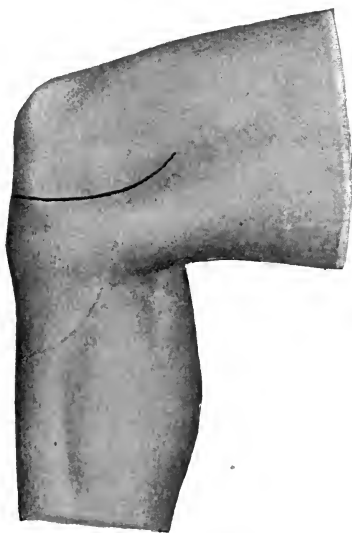


FIG. 142.—Resection of the knee-joint: anterior arched incision by the method of Textor.

tremity flexed at the knee-joint and unites the most prominent points on the lateral aspects of the condyles of the femur by an anterior arched incision passing from left to right and dividing the patellar ligament (Textor, Fig. 142). The incision enters the joint, which is opened adequately upon its anterior aspect (Fig. 143). The thumb of the left hand is passed into the articular interval between the patella and the femur, and separates the at-

tachments of the capsule laterally to the condyles of the femur, when by reflecting the patella the sacculated diverticulum of the capsule is visible from above. The crucial ligaments and the accessory lateral ligaments are now divided. The lower extremity of the femur is thus exposed and, after the periosteum has been incised cir-

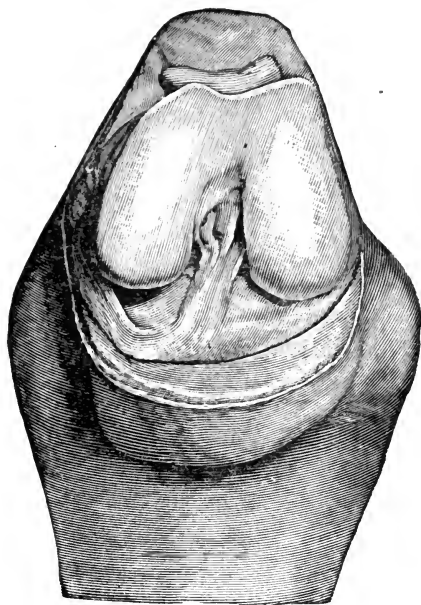


FIG. 143.—Knee-joint opened through the anterior arched incision.

cularly above the condyles, the bone is grasped with Langenbeck's forceps and sawed transversely. König makes the sawed surfaces in such a plane that the joint is placed in a position of slight flexion. If it be necessary to remove also the upper articular surface of the tibia, this is brought out of the wound, surrounded by a circular incision, and removed in the form of a plate. In sawing

the bone it is grasped with the forceps at the intercondyloid eminence and fixed. If the patella is to be removed, it is surrounded by an incision and freed with strokes of the knife passed close to the bone. The sawed surfaces of the bones are approximated and fixed in apposition by means of sutures, clamps, or pegs.

According to the method of Volkmann, the anterior transverse incision passes from one condyle to the other over the middle of the patella. The periosteum is incised transversely and the patella is sawed through on a line with the cutaneous incision. In the prolongation of the incision through the patella the capsule is incised to the right and the left and the joint is widely opened. The knee is now strongly flexed at an acute angle, so that the incision into the joint is made to gape widely and the lateral ligaments, as well as the lateral attachments of the capsule, are divided. The crucial ligaments are divided from behind forward. The upper segment of the patella is reflected by traction, and the interior of the capsule becomes accessible. The lower extremity of the femur is surrounded by a circular incision, grasped with forceps at the inner condyle, and divided transversely with a saw.

In Hahn's modification the transverse incision passes above the patella (Fig. 144).

Resection of the Knee-joint with a Lateral Hooked Incision by the Method of Kocher.—The incision is made on the outer side of the knee-joint, and begins at the vastus externus muscle, a hand's breadth above the patella, two fingers' breadth from whose outer border it passes downward, to terminate upon the inner aspect of the tibia below its spine.

In the wound the broad fascia is divided. The capsule of the joint is approached from the outer side of the exposed external vastus, and the joint is opened in this situation. The tuberosity of the tibia, in connection with the proper ligament of the patella, is chiseled off, when, if the capsule is slit throughout the entire length of the in-

Plate 16.—Resection of the Knee-joint by the Method of Kocher (Right Leg).

The joint is opened from the outer aspect. The proper ligament of the patella has been chiseled off with the tuberosity of the tibia (*Tu*), so that the inner border of the wound, together with the patella (*P*), can be strongly retracted inward. The constituents of the joint, the condyles of the femur (*F*), the upper extremity of the tibia (*Ti*), are exposed. The capsule is adequately accessible in all of its diverticula. The alar ligaments (*A*) are visible. The synovial pocket beneath the tendon of the rectus muscle also is conveniently exposed.

cision, free access to the joint will be afforded by retraction

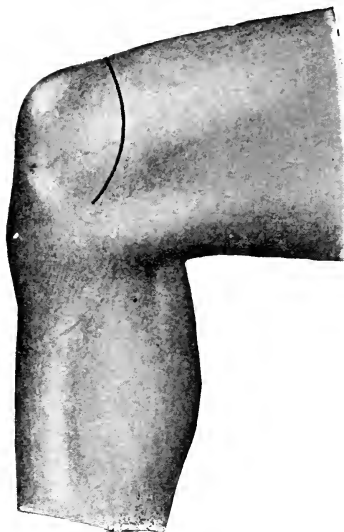
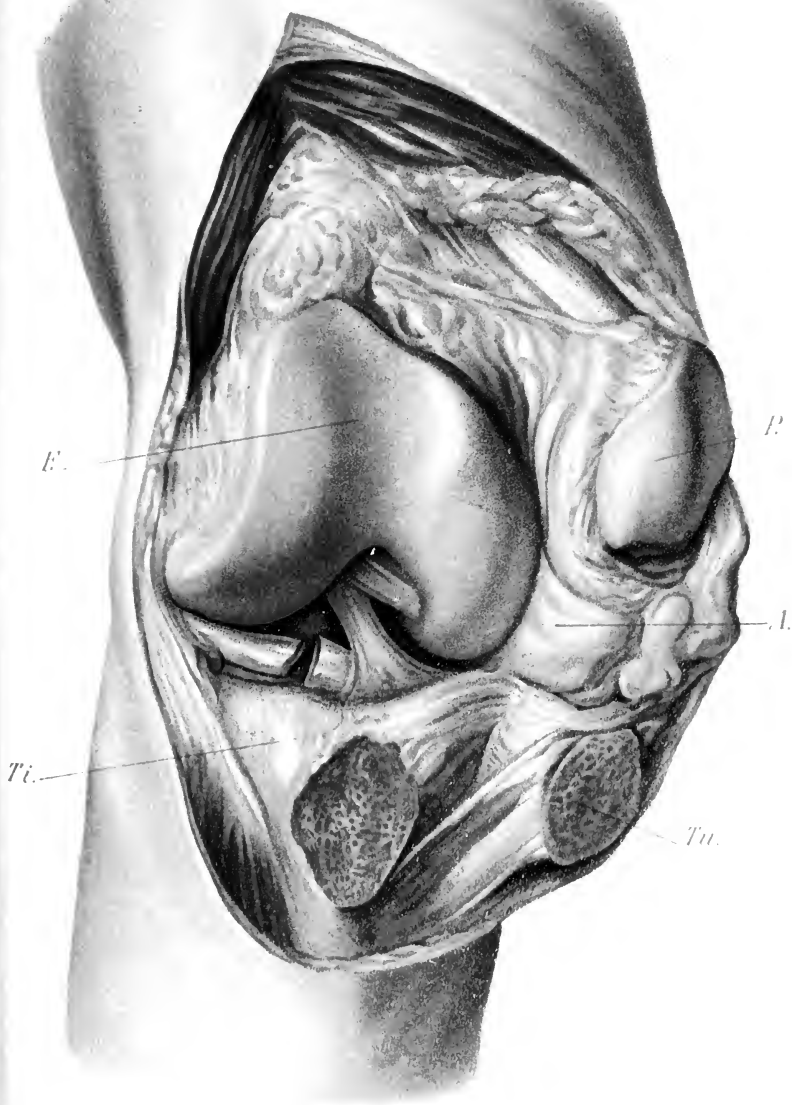
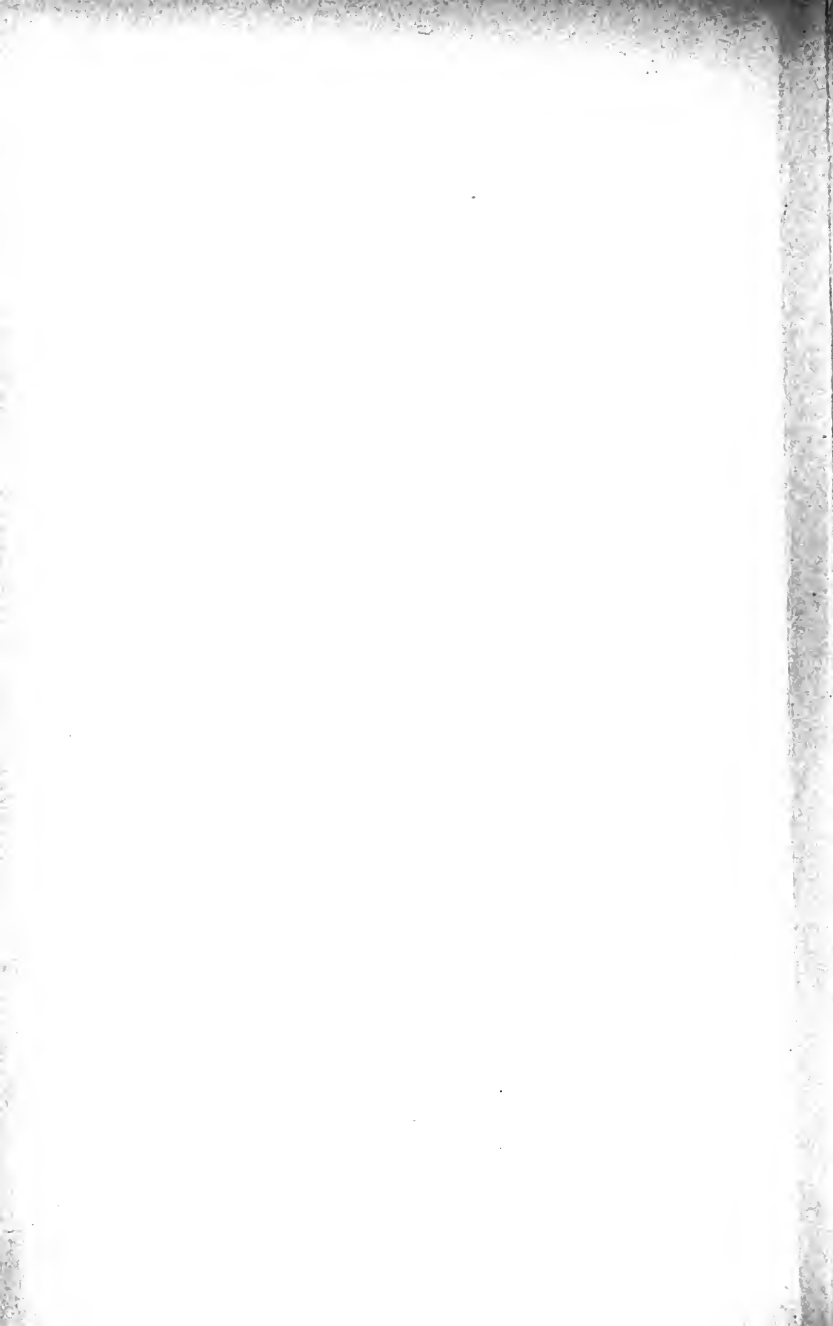


FIG. 144.—Hahn's suprapatellar incision for resection of the knee-joint.

of the movable patella inward and reflecting it (Plate 16). The synovial surface of the joint, with all its diverticula, is sufficiently exposed. Should resection of the articular extremities be required, the crucial ligaments are





divided, when the bones will have to be isolated only to the desired degree. Before the femur is sawed through, Kocher, in order to preserve the ligamentous attachments, separates the epicondyles with a chisel, so that they can be displaced backward in connection with the periosteum.

Resection of the Ankle-joint.—*Bilateral Longitudinal Incision after Langenbeck.*—The longitudinal incisions begin on either side, a hand's breadth above the malleoli, and pass along the tibia and fibula beyond their lower extremities. The incisions pass through skin and periosteum. With the foot lying upon its inner border, the fibula is dissected free beneath the periosteum with a knife or a raspatory on its outer and inner aspects, and is divided in a linear direction above the malleoli with chisel and mallet or with the chain-saw. The peripheral fragment of the bone is reflected outward and separated from its attachments. In an analogous manner the lower extremity of the tibia is excised through the internal longitudinal incision. By the removal of the malleoli a view can be had of the interior of the joint, and the trochlear surface of the astragalus, as well as the walls of the capsule, is rendered accessible for further operative procedures.

Langenbeck has obtained the most admirable results with this conservative method of resection following gunshot-injuries of the ankle-joint, and especially transverse wounds with destruction of both malleoli. The operation is less well adapted for the modern procedure of arthrectomy, as the lower extremities of the fibula and tibia are sacrificed, at any rate, and, besides, the opportunity for inspection of the joint afforded through the incisions is not adequate to meet the needs of extirpation of the capsule.

König's Bilateral Longitudinal Incision.—The incision on the inner aspect begins 3 or 4 cm. above the level of the articulation upon the tibia, somewhat internal to the extensor tendons, and it opens the joint close to the anterior border of the inner malleolus. It passes over the body and neck of the astragalus, to terminate at the

Plate 17.—Resection of the Ankle-joint by the Method of Kocher.

The foot is completely dislocated upon the inner malleolus. The ankle-joint is in this way well exposed to view. The bony constituents of the joint are visible: Trochlear surface of the astragalus (*T*) and bones of the leg (*U*). The tendons of the peroneal muscles (*P*) are divided. In the background of the wound are the tendons of the flexors (*F*) and the bundle of vessels, the posterior tibial artery and accompanying veins (*V*).

inner border of the foot at a point corresponding with the tuberosity of the scaphoid bone. The outer incision runs parallel with the inner, along the anterior surface of the

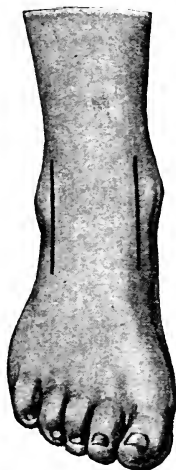
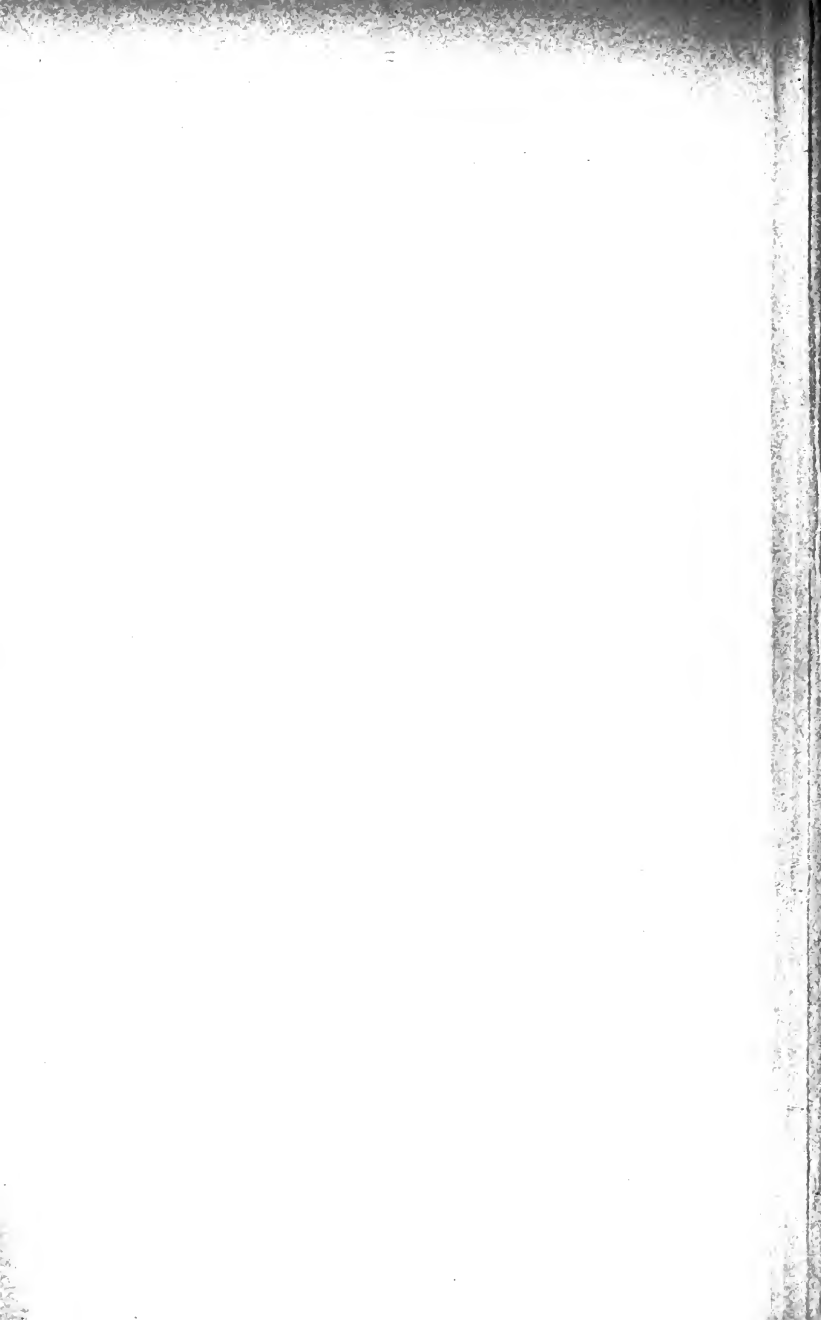


FIG. 145.—Resection of the ankle-joint through König's bilateral longitudinal incisions.

tibia, opens the joint at the malleolus, and terminates at the level of the astragaloscaphoid articulation (Fig. 145). The anterior bridge of skin, which contains the extensor tendons, the vessels, and the nerves, is dissected from the subjacent tissues, the insertion of the capsule being at the





same time detached transversely from the trochlea of the astragalus and the border of the tibia, and if necessary the anterior portion of the synovial membrane is excised. By lifting up the bridge-like flap, with dorsal flexion of the foot, the individual portions of the joint may be made accessible to the eye and to instrumental manipulation. The removal of the astragalus is readily effected through the inner incision, when the articular surface of the tibia and the posterior wall of the capsule become visible.

Reverdin-Kocher Method of Luxation through an Ex-



FIG. 146.—Resection of the ankle-joint: skin incision (after Kocher).

ternal Arched Incision.—The incision begins at the tendo Achillis, about a hand's breadth above the malleolus, passing downward, surrounding the external malleolus, and terminates on the outer border of the foot along the outer margin of the extensor tendons (Fig. 146). After division of the skin and exposure of the external malleolus the accessory ligaments of the capsule inserted in this

situation are divided. The attachment of the capsule is freed, with displacement of the extensor tendons, and, if necessary, division of the peroneal tendons upon the anterior and posterior aspects of the tibia, when the foot is flexed upward in such a manner over the internal malleolus that its inner border is brought in contact with the inner aspect of the tibia (Plate 17). The joint is thus made accessible to inspection, and necessary operative procedures upon the articular extremities, as well as upon the capsule, may be undertaken.

Resection of the Foot by the Method of Wladimiroff and Mikulicz.—Indications :

(1) *Caries* of the foot localized in the calcaneum, the astragalus, and the ankle-joint.

(2) *Extensive loss of substance* about the heel.

(3) *Injuries* of the heel, especially gunshot wounds.

(4) *Malignant tumors* about the heel (osteosarcoma, melanosarcoma) (Bruns).

(5) *Shortening* of the extremity, following luxations of the hip-joint (Caselli) or resections of the knee-joint (Rydygier).

(6) *Paralytic club-foot* (Bruns).

The parts removed in the resection include the lower extremities of the tibia and the fibula, the astragalus, the calcaneum, and a portion of the cuboid and scaphoid bones in conjunction with the skin of the heel. The anterior portion of the foot is maintained in relation with the leg by means of a dorsal bridge containing the tendons and vessels.

Mode of Procedure.—A transverse incision is made through the sole of the foot corresponding to the extremities of Lisfranc's line, and a second transverse incision is made above the malleoli on the posterior aspect of the leg, the extremities of both being united by additional lateral incisions (Fig. 147). The ankle-joint is opened from the posterior aspect and stretched widely, and the bones of the leg are divided transversely above the malleoli. The root of the foot is grasped at the trochlea of

PARTIAL RESECTION OF THE FOOT BY THE METHOD OF WLADIMIROFF-MIKULICZ.

FIG. 147.

Cutaneous incisions.

FIG. 148.

Configuration of the foot after resection has been effected. The sawed surfaces of the bones of the leg, as well as those of the cuboid and scaphoid bones, are exposed.

FIG. 149.

Appearance of the stump.

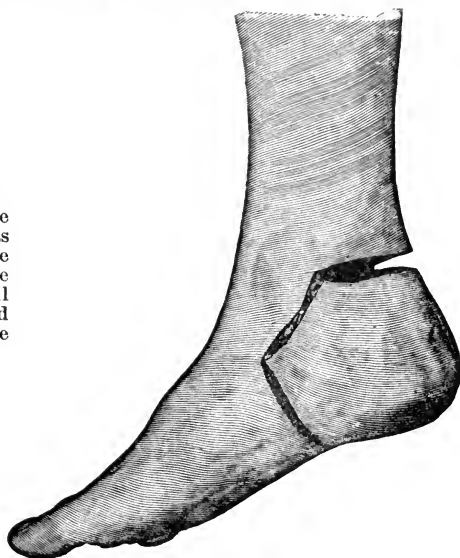


FIG. 147.



FIG. 148.

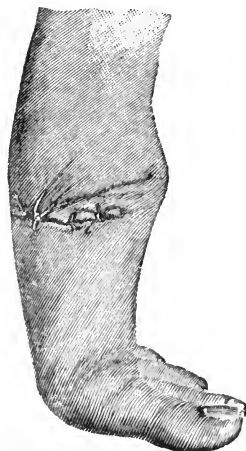


FIG. 149.

the astragalus, and it is freed close to the bone from the dorsal soft parts, with maximum dorsal flexion of the foot. In accordance with the extent of tissue to be removed the tarsus is sawed through in the region of the cuboid and scaphoid bones, or further to the distal (at the base of the metatarsal bones) or to the proximal side. When the operation is performed for orthopedic reasons, only the calcaneum and the lower extremities of the tibia and the fibula are removed, together with the trochlea of the astragalus. Inasmuch as after the resection has been effected the sawed surfaces of the bones of the leg and the tarsus are approximated and united by bone-suture, there results an artificial club-foot to such a degree that the dorsum of the foot lies in the same plane as the anterior aspect of the leg (Figs. 148 and 149).

In performing *tibiocalcaneal resection* by the method of Bruns, the ankle-joint is opened through an arched dorsal incision, the astragalus freed, and the lower extremities of the tibia and the fibula, as well as the upper surface of the calcaneum, sawed through transversely, when the sawed surfaces are nailed together.

Osteotomy.—Osteotomy consists in linear division of a long bone after incising the soft parts. Originally performed through a free open wound, the operation has since the time of Langenbeck been performed, like tenotomy, through a small incision in the skin, in a measure subcutaneously. The division of the bone is effected with the aid of chisels [and osteotomes.—ED.].

The extremity is placed upon a board or upon a sand-bag, the Esmarch apparatus is applied, and the operation of osteotomy is undertaken. A short incision through the soft structures penetrates down to the bone. With slight blows of the mallet a chisel is driven into the bone. After it has penetrated it is removed, and a similar process is gone through in a neighboring situation. In this manner the cortical structure of the bone is successively divided transversely throughout almost its entire circumference. The remainder is fractured by forcible bending, and the extremity, after the cutaneous wound has been

properly united, is fixed in an appropriate position in a plaster-of-Paris dressing.

In cases in which simple linear osteotomy will no longer suffice, wedge-shaped excisions are undertaken for the correction of ankylosis, or curvature of high degree. The base of the wedge corresponds always with the convexity of the curvature to be corrected. After adequate exposure of the bone and division and detachment of the periosteum, the wedge is removed with the chisel or the saw, when the correction of the deformity may be readily effected.

A special form of osteotomy employed for the correction of marked arcuate curvature of the long bones consists in longitudinal division, the bone being divided in a direction parallel with its long axis. The displacement of the segments of bone in the axis of the part renders possible to a certain degree correction of deformity.

Osteotomy of the femur at the upper extremity of the bone is undertaken in cases of contracture of the thigh, if the correction of the faulty position is attended with difficulty after division of the contracted soft parts. Linear osteotomy under these circumstances is undertaken either at the neck of the femur (*osteotomia colli femoris*), or at a point between the two trochanters (*osteotomia intertrochanterica*). For the exposure of the upper extremity of the femur a longitudinal incision over the trochanter is made upon the postero-external aspect of the joint. In this situation the neck of the femur can be exposed for osteotomy, as well as a deeper portion of the bone after separation of the muscular attachments to the greater trochanter.

Supracondylar osteotomy of the femur has been recommended by Macewen as a routine procedure in the treatment of genu valgum. According to Macewen's recommendation, the short cutaneous incision on the inner aspect of the lower extremity of the femur is made at a point corresponding to the intersection of two lines, of which one passes a finger's breadth above the upper border of

the internal condyle, and the other in the longitudinal axis of the bone, two fingers' breadth in advance of the tendon of the adductor magnus. At the point of intersection of these two lines a short longitudinal incision is made down to the bone, the osteotome introduced through the wound, applied transversely, and the cortical structure of the bone successively divided throughout two-thirds of its circumference. The remainder of the bone is severed by manual means. Supracondylar osteotomy of the femur may also be undertaken from the outer side of the bone in a corresponding situation.

Linear osteotomy, as well as excision of wedge-shaped portions, may be undertaken upon the bones of the leg for the correction of deformities at the knee-joint, or of excessive curvature. The tibia is exposed at its upper extremity, from 4 to 6 cm. below the articular line, by means of a transverse incision around the inner circumference of the bone (Kocher). After detachment of the periosteum the bone is divided with the chisel in the direction of the cutaneous incision.

Excision of a wedge-shaped portion of the tibia may also be effected through the same incision.

II. OPERATIONS ON THE HEAD AND NECK.

Trephining.—Trephining consists in resection of the bones of the skull in their continuity. The term is applied equally to the excision of small circular segments and the establishment of a penetrating defect in the skull, to the temporary removal with a chisel of a portion of the bone in conjunction with the periosteum and the skin, as well as to the removal of loose depressed splinters, the elevation of the indented calvarium, and the correction of irregularities in wounds following injuries of the skull.

Indications :

(1) *Injuries of the Calvarium.*—Open or subcutaneous fractures ; if the bones exhibit depression ; if the vitreous table is splintered ; if foreign bodies have penetrated into the bones.

(2) *Injuries of the Brain and its Membranes.*—If the brain-tissue is crushed ; if fragments of bone or foreign bodies have penetrated the brain ; finally, if the symptoms indicate a considerable extravasation of blood.

(3) *Caries and necrosis of the cranial bones.*

(4) *Tumors of the skull.*

(5) *Purulent inflammation of the cerebral membranes, cerebral abscess, sinus thrombosis.*

Further, the skull has been opened for the purpose of gaining access to the *ventricles of the brain*, or of exposing portions of the cerebral cortex for excision (epilepsy). Trephining has been recommended also in cases of chronic increase of intracranial pressure, of microcephaly, and of idiocy.¹

In general, the operation is performed in such a way that after division of the scalp, the aponeurosis of the

¹ In insanity of traumatic origin, in which the seat of initial trouble is made manifest by a scar, a persistent headache, or muscular phenomena of a local character, it may be proper to trephine. The operation is, however, rarely justifiable in insanity, and will not often be productive of benefit.—ED.

occipitofrontal muscle, and the pericranium, a suitable segment of bone is removed with the crown of the trephine, the chisel and mallet, or the circular saw. The exposed dura is either opened with a crucial incision or is reflected back as a flap, and after the operation has been finished it is closed with catgut-sutures. The deficiency in the bone established either remains open or it is closed. Under the condition first named, the skin being utilized to cover the defect in the bone, the opening becomes closed by connective tissue, a result that is attended with certain disadvantages. It has therefore become the rule, whenever the nature of the case renders it permissible, to close the trephine-opening by means of bone. This may be effected:

1. By reimplantation of the piece of bone trephined ;
2. By autoplasty or heteroplasty ;
3. By temporary resection of the cranial bones, employed from the outset as a substitute for typical trephining.

The restored button of bone should at the present time, under aseptic conditions, heal in place in all cases ; but reimplantation has been successfully undertaken by Ph. v. Walter.

Autoplasty, an ingenious procedure devised by König, consists in the transplantation upon the defect of a pedunculated flap consisting of skin, periosteum, and a portion of the cortical structure separated with a chisel. The defect resulting from the formation of the flap is covered with a pedunculated cutaneous flap removed from the adjacent region.

Heteroplasty consists in the insertion of a foreign body, which should heal in place. A. Fränkel has successfully employed *celluloid* plates for this purpose.¹

Mode of Performing Trephining.—1. *By Means of the Trephine.*—A linear incision is made in the scalp (in a

¹ The observations of Barker indicate that after a piece of living bone has been transplanted it undergoes anemic necrosis. New, living tissue takes its place, but the transplanted piece does not live. In fact, it seems probable that dead bone is as valuable in filling a defect as is living bone.—ED.

radiating direction), or a flap is outlined (with its base below).¹ After the periosteum has been divided, it can be detached from throughout a sufficient extent by means of a raspatory. The *trephine*, a hollow cylinder with toothed edges, is applied to the bone. The axis of the crown of the trephine, a steel rod with a sharp point, is bored into the bone and secures uniformly firm application of the saw-edge. By rotatory movements of the crown of the trephine the instrument penetrates the bone. When, after the first rotatory movements, the teeth of the instrument have entered the bone, the pressure and the rotation are continued in even, though slighter, degree. The groove made by the saw is frequently cleaned and examined as to its depth. As soon as the fragment of

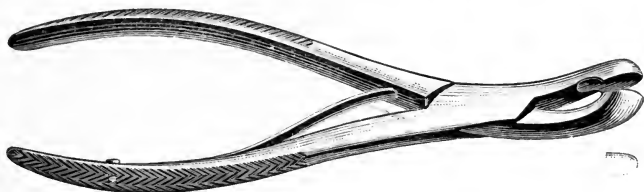


FIG. 150.—Luer's gouge-forceps.

bone is loosened it is grasped with the *tirefond*, a gimlet-like instrument, and is removed.² By means of a special instrument, known as the lenticular, it was customary in the past to smooth the margins of the opening. If the opening made proves to be too small, it may be enlarged with the aid of the chisel and the mallet, or a second opening may be made with the trephine in *immediate contiguity*.

2. *With Chisel and Mallet.*—This is preferable to the

¹ In most cases a U-shaped flap, the base of which carries the blood-supply, the pericranium being raised with the scalp, gives the best exposure and is followed by the most rapid union.—ED.

² Instead of employing a special instrument to lift out the button, the bit of bone can be forced out by means of a periosteum elevator or a blunt dissector used as a lever.—ED.

operation with the trephine in so far as the shape and the size of the opening in the bone can be adapted to the needs of the individual case. The scalp, together with the periosteum, is dissected from the bone in the form of a flap, with its base below, and reflected back. With the chisel the outline of the portion of bone to be removed is marked out, and this is deepened uniformly at all points. In the groove made with the chisel the point at which the vitreous table has been passed can be determined by

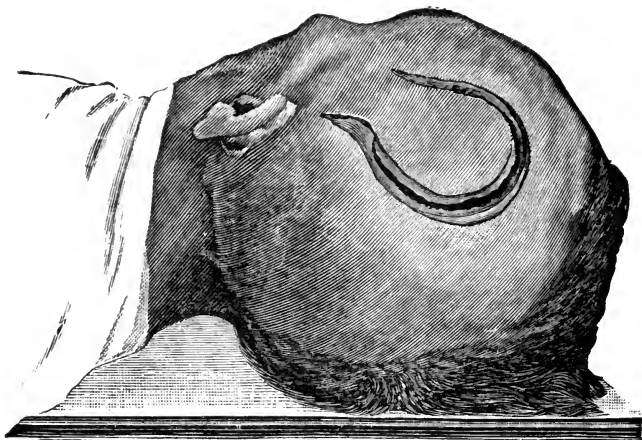


FIG. 151.—Osteoplastic resection of the skull. Form of the cutaneous flap: the portion of bone to be removed has been outlined with the chisel.

careful palpation with the sound. When the disk of bone is free, it is removed from the opening with an elevator.

The mode of procedure does not follow this typical course in cases of fracture of the skull. The soft parts are divided in the manner described. Completely separated splinters that have been forced into the brain are to be removed, depressed portions of bone are to be raised, and sharp margins are to be cut off, etc. For elevating

and removing fragments of bone Luer's gouge-forceps (Fig. 150) may be employed; for enlarging fissures in bones the chisel and mallet are employed exclusively.

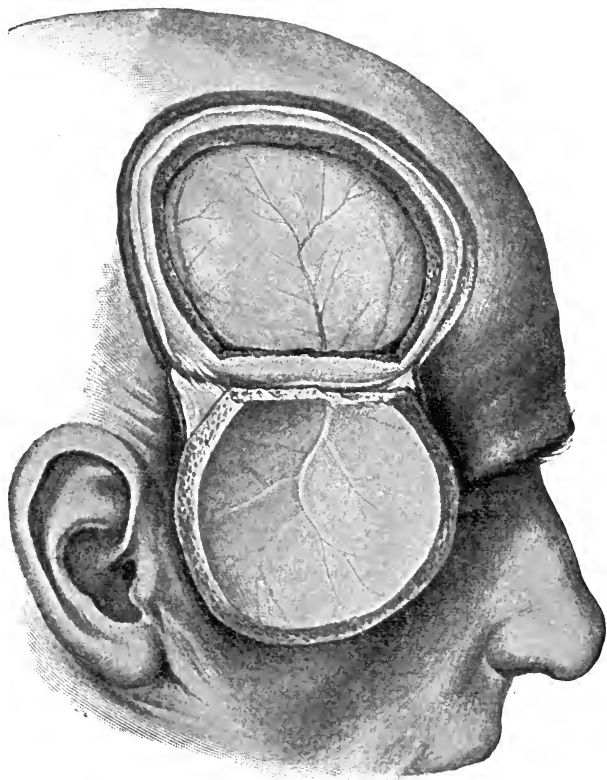


FIG. 152.—Osteoplastic resection of the skull. The bone-flap together with the skin is reflected back, and the dura and the ramifications of the middle meningeal artery can be seen. .

Osteoplastic Resection of the Skull.—*Temporary resection of the skull* (Wagner, Wolff, Ollier) has of late almost replaced the classic mode of trephining. In employing

this method the disc of bone sawed out or chiseled out retains its natural connection with the periosteum and the scalp. After the operation has been completed, the

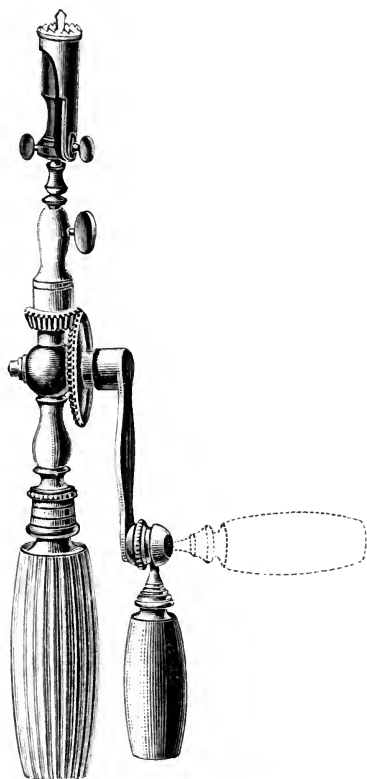


FIG. 153.—Collins' perforator, provided with a small trephine-crown.

flap of bone and soft parts is restored to its original position, where it heals. Wagner incises the skin in the shape of a lyre or of an omega (Ω -shaped) (Fig. 151), the incision passing down to the bone at all points. A furrow is chiseled into the bone corresponding to the quadrant, and the groove is gradually deepened by means of chisel and mallet until the dura is reached. At the base, corresponding with the narrowest portion of the flap, the bone is divided with a single stroke upon the chisel, when the flap of integument, periosteum, and bone can be reflected (Fig. 152). After the intracranial manipulation has been completed the bone is replaced in the artificial opening and the cutaneous wound is closed by suture.

Originally (Wagner), in performing resection of the skull, the bone was always divided with chisel and mallet. In order to obviate the disadvantages of this method, particularly the concussion of the skull, Salzer introduced

the employment of the circular saw ; as by this means it is not possible to know at all times the depth to which the saw is cutting, only a deep groove in the bone was

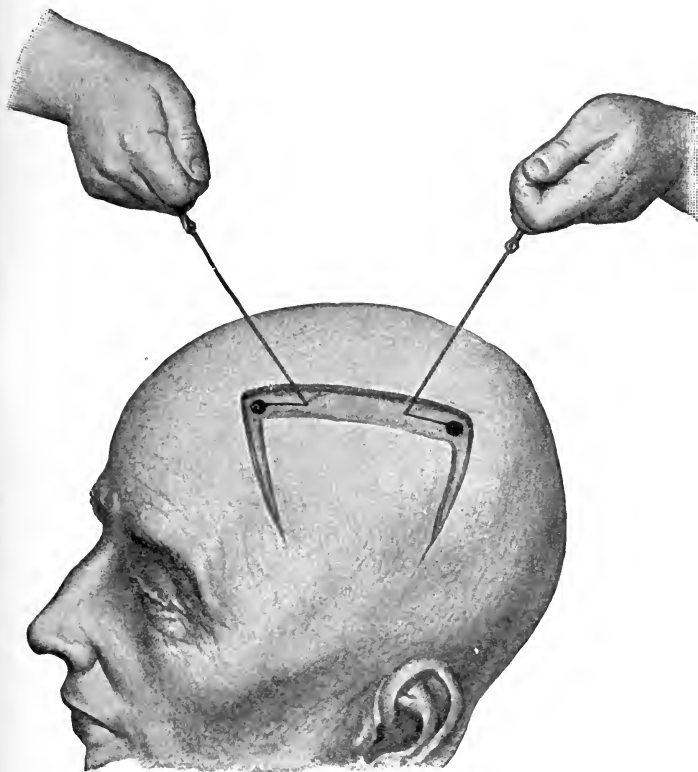


FIG. 154.—Osteoplastic resection of the skull by means of the wire saw, according to the method of Obalinsky.

sawed with this instrument in order to avoid injury of the dura and the brain, and the vitreous table was divided with chisel and mallet. Forceps-like instruments also have been constructed (Dahlgren), by means of which the

cranial bones can be divided without concussion. By means of Gigli's wire-saw Obalinsky divides the bones from within outward. A tongue-shaped flap of the soft parts covering the skull is cut, and, by means of a Collins perforator (Fig. 153), from five to seven holes are bored at various points upon the exposed bone, between which the dura mater is detached from the skull by means of delicate separators. With the aid of a probe, to which the saw is tied, a wire saw can be passed from one opening to another. The bone is divided from within outward without any concussion (Fig. 154). Also at the base of the flap the bridge of bone is divided in an analogous manner.

While the flap upon the skull is, as a rule, made of limited extent, Doyen has performed temporary resection of the skull in the most extensive degree in order by this means to render accessible an entire cerebral hemisphere. The incision passes from the root of the nose over the vertex to the occipital protuberance, and from this point to the root of the ear and the malar bone. Doyen bores a number of holes in the course of the incision, avoiding the longitudinal sinus, and divides the bridges with an electric circular saw. The temporal fossa is fractured, and the bone is reflected back.

Determination of the Points for Trephining upon the Skull.—There are numerous methods for projecting upon the surface of the skull the surgically important parts of the brain, such as the Rolandic fissure, the Sylvian fissure, the branches of the middle meningeal artery, and in this way to determine with certainty the site of operation. At the present day, as large portions of the brain can be exposed by osteoplastic resection, the minute calculations are no longer of the same importance as formerly. Krönlein endeavored to replace the absolute figures for localization by measurements that varied proportionately with the dimensions of the skull in the individual case. The formula of Krönlein, which will be mentioned as the simplest, renders possible the determination of the most important

localizations upon the basis of a geometric diagram without the aid of figures. For this purpose the following lines are drawn (Figs. 155 and 156):

1. A *horizontal auriculo-orbital line* (through the infra-orbital margin and the external auditory canal).

2. A *horizontal supra-orbital line* (parallel with the former) through the supra-orbital margin.

3. An *anterior vertical line* (from the middle of the zygoma vertically to the horizontal lines).

4. A *middle vertical line* (through the maxillary articulation, parallel with the preceding).

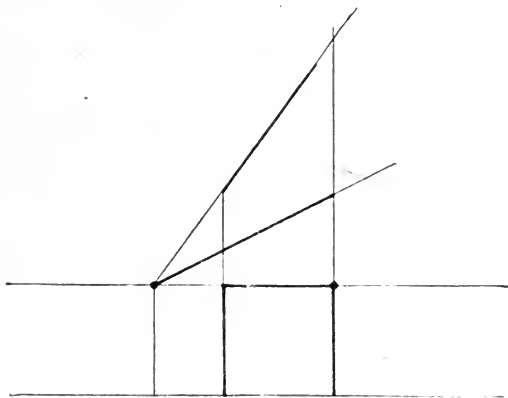


FIG. 155.—Kronlein's diagram for craniocerebral topography.

5. A *posterior vertical line* (through the most posterior point of the mastoid process).

The oblique line passing from the intersection of the upper horizontal and the anterior vertical line to the intersection of the posterior vertical line and the sagittal middle line upon the skull corresponds with the direction of the central fissure. The line dividing equally the angle between this Rolandic line and the upper horizontal line corresponds with the direction of the Sylvian fissure. The points of intersection between the middle and pos-

terior vertical lines with the upper horizontal line correspond with Krönlein's points of trephining for finding the middle meningeal artery. The field included between the middle and posterior vertical lines and the supra-orbital and

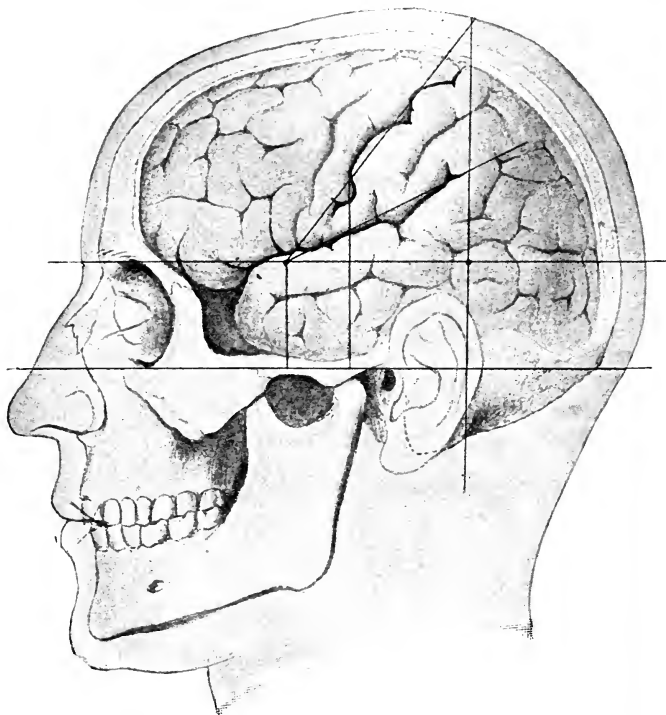


FIG. 156.—Krönlein's diagram for craniocerebral topography, projected upon the surface of the brain (after Krönlein).

infra-orbital lines represents Bergmann's area for trephining for otitic abscess of the brain in the temporal lobe.

The slight deviations present in various types of brain are, as Krönlein has been able to show, of no practical importance with regard to the foregoing method of localization.

Trephining of the Mastoid Process.—The operation is undertaken in the presence of acute inflammation of the middle ear, of chronic suppuration of the middle ear, of cholesteatoma, of fistulæ, of caries, and of necrosis. In accordance with the extent of the morbid process only



FIG. 157.—Trephining of the mastoid process. In the opening made, the entrance to the antrum is visible. To the outer side is the sigmoid sinus.

opening of the cells of the mastoid process is undertaken, or with this operation is conjoined exposure of all the cavities of the middle ear (Küster, Zaufal, Staacke).

Opening of the Cells of the Mastoid Process.—A longitudinal incision is made behind the ear, over

the mastoid process, through the skin and the periosteum, down to the bone (Fig. 157). The periosteum is detached from the bone on either side, and the mastoid process is thus exposed throughout the desired extent. With the aid of the chisel an oval opening from 15 to 20 mm. in diameter is made in the cortical structure behind the external auditory canal, just external to the spine, above the meatus. Carefully using a small gouge, step by step, advance is made in the depth. The object of the operation is to expose all the purulent area in the bone, and, with the aid of the chisel and the mallet, and also with that of the sharp spoon, to establish a cavity surrounded by healthy walls. In advancing in the depth a course should be pursued parallel with the posterior superior wall of the bony portion of the auditory canal. By penetrating vertically into the depth there would be danger of injuring the lateral sinus. Above, the cavity of the skull might be entered through the roof of the tympanum, and below, the facial nerve might be injured. The direction of the wound-canal is thus forward, following the posterior superior wall of the auditory canal. In children the trephine opening is made correspondingly smaller. The wound remains open.

Operative Exposure of the Cavities of the Middle Ear.—The cutaneous incision and exposure of the mastoid process are effected in the manner described. The cutaneous portion of the auditory canal is detached from the bone, and together with the auricle is retracted strongly forward. The cells and the entrance to the antrum are exposed in the manner previously described. By removal in layers of the posterior superior wall of the auditory canal covering the antrum the tympanic cavity and the epitympanic recess are rendered accessible. The recess, the antrum, and the cavity of the mastoid process thus represent a widely open space. In the antrum is the arcuate eminence of the lateral semicircular canal, and beneath this the canal for the facial nerve, with the sigmoid sinus visible at the mastoid process (Fig. 158).

The wound remains open. After longitudinal division of the cartilaginous portion of the auditory canal two flaps can be constructed from this, which, reflected into the wound-cavity, heal in this situation and render possi-

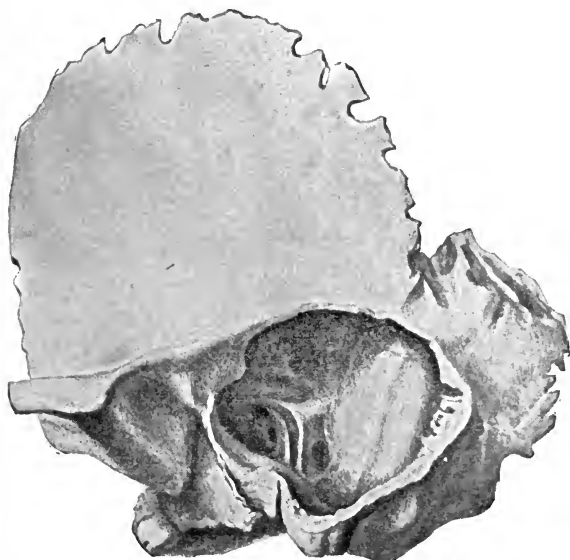


FIG. 158.—The opened cavities of the middle ear (after a preparation of Professor Politzer).

The anterior wall of the mastoid process has been removed, and the posterior superior bony wall of the auditory canal has been chiseled away. The cavity of the mastoid process, the tympanic antrum, and the epitympanic recess represent a large communicating space. In the antrum is seen the arcuate eminence of the external semicircular canal, and beneath this the canal for the facial nerve, and in the mastoid portion is the sigmoid sinus.

ble speedy covering of the large cavity. Staacke enters directly into the epitympanic recess and not by way of the cavity of the mastoid process, and opens the antrum from that point. A cutaneous incision is made behind the auricle. The cutaneous portion of the auditory canal

is detached, divided, incised, and, together with the auricle, is reflected forward. After removal of the malleus and the remainder of the tympanic membrane, under the protection of a small raspatory introduced high into the attic, the outer and lower wall of the epitympanic recess is cut away, and the incus is removed, when, after chiseling away the posterior and upper wall of the auditory canal, the antrum becomes accessible. If the cortical structure also has been chiseled away, the entire cavity of the middle ear lies free. The divided auditory canal is retracted into the wound in the form of two flaps.

Should the necessity arise, in the presence of cerebral symptoms in connection with suppuration of the middle ear, to open the skull, the way to this is through the cavity of the middle ear, exposed in the typical manner. Frequently the caries of the bone indicates the path to be followed. If this is not the case, a circumscribed piece of bone should be chiseled out of the roof from the summit of the arch of the antrum, in order to reach the temporal lobe, the most frequent seat of cerebral abscess of otitic origin. In order to reach the cerebellum the opening in the bone is enlarged in an outward direction until the sinus and a portion of the dura beneath this are adequately exposed. If the latter is incised in this situation, the cerebellum will be rendered accessible. The method of exposure of the transverse sinus for purposes of incision and evacuation in the presence of thrombosis will be evident from the rules laid down for trephining the mastoid process.

Opening of the Frontal Sinus.—Opening of the frontal sinus is indicated in the presence of accumulations of pus and tumors in this cavity. The frontal sinuses (Fig. 159), separated from each other by a septum, extend, as a rule, far into the orbital portion of the frontal bone, although they exhibit great individual variations in form and extent. The cavity can be reached most certainly by entering just above the orbit on a line corresponding with the superciliary arch (Fig. 160). A curved

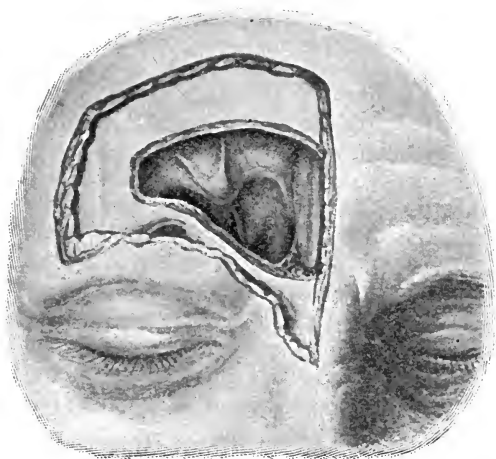


FIG. 159.—Frontal sinus.
(From a preparation of Court-Physician Zuckerkandl.)



FIG. 160.—Trephining of the frontal sinus.

incision is made through the soft parts down to the bone. The frontal and supra-orbital nerves are thereby divided. The periosteum is detached, and at the inner extremity of the arch the cortical structure is penetrated with the chisel, the trephine, or the perforator, and the mucous membrane of the cavity—that is, the anterior wall of the sinus—is incised. The opening is made of varying size, in accordance with the purposes for which the operation is undertaken. Drainage of the frontal sinuses can be established through the nose by means of a tube, the cutaneous wound being completely closed.

Operations on the Jaws.—Opening of the Maxillary Sinus.—This operation is indicated in the presence of empyema and chronic hydrops of the antrum of Highmore. The maxillary sinus can be opened :

1. Through the canine fossa.
2. Through the nasal cavity.
3. Through the alveolar process.

In order to open the antrum through the canine fossa the mucous membrane is divided transversely for two or three centimeters at the line of reflection from the upper lip to the maxilla, at a point corresponding to the second bicuspid tooth, while the lip is elevated. The mucous membrane and the periosteum must be detached from the bone for a short distance within the range of the wound until a sufficient portion of bone is exposed. In this situation an opening is made in the bone by means of a perforator, a trephine, or a gouge, and after division of the mucous membrane a cavity is opened (Fig. 161). Accordingly as the empyema is recent or of some standing, a smaller or a larger opening in the bone will be required.

The maxillary sinus is opened through the alveolar process at a point corresponding to the second bicuspid or the first molar tooth. The root of the tooth in question is first extracted, and with the aid of a gimlet-like instrument (hand trephine of Chiari or the augur of Hajek) an entrance is forced through the alveolus into the maxillary sinus. An obturator with a plug filling the canal and

reaching into the maxillary sinus must often be worn for a long time until complete healing has taken place. Opening of the maxillary sinus is undertaken through the inferior nasal meatus with the aid of a curved trocar. The instrument, under guidance of a speculum, is introduced up to the middle of the inferior nasal meatus, with

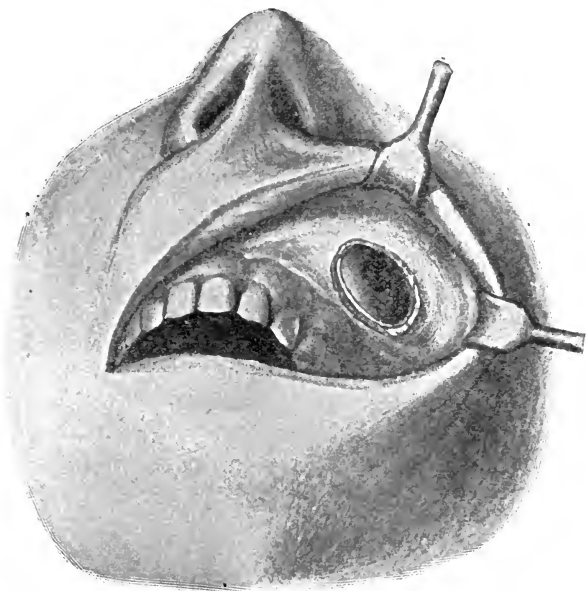


FIG. 161.—Opening of the maxillary sinus through the canine fossa.

its point directed outward toward the external wall of the nasal cavity, and with a push it is forced through the wall into the sinus. The stilet of the trocar is removed, and the cannula is employed for irrigation of the cavity.

Resections of the Jaws.—**Resection of the Upper Jaw.**—The upper jaw is removed partially or wholly when the seat of malignant disease.

Temporary resection of the upper jaw may be undertaken

to expose the nasopharynx, the sphenomaxillary fossa, or the temporal fossa, for purposes of operative intervention. The body of the upper jaw presents three processes through which it articulates with neighboring bones. The palatal process unites in the middle line with a similar process of the bone of the opposite side. The frontal or nasal process unites the upper jaw with the frontal bone, and the zygomatic process unites it with the malar bone. The posterior surface of the body of the upper jaw is united with the descending wing of the sphenoid and with the

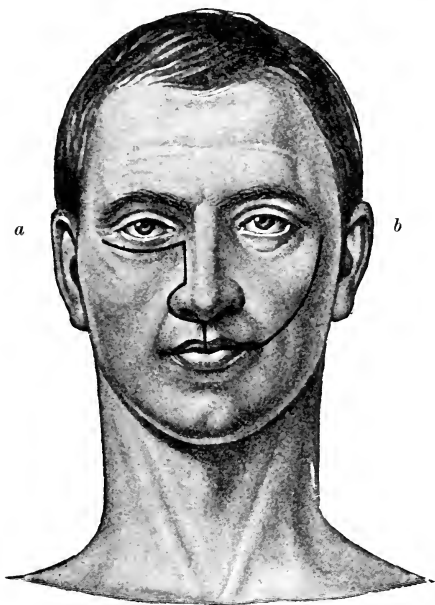


FIG. 162.—Incisions for resection of the upper jaw: *a*, by Weber's method; *b*, by Velpeau's method.

pyramidal process of the palatine bone. These processes must all be severed if the upper jaw is to be separated from its attachments.

Mode of Performing Resection of the Upper Jaw.—The head of the patient is placed on a lower level than the trunk. Preliminary tracheotomy and the introduction of a tampon-cannula are not necessary. The cutaneous incision (Weber) is immediately made at all points down to the bone. It begins at the middle of the upper lip, which it divides vertically, surrounds the nasal ala on the side to be operated upon to its upper extremity, having reached the upper extremity of the ala of the nose, continues vertically upward to the internal canthus of the eye, and thence at an acute angle passes outward along the lower margin of the orbit, to end at the external canthus of the eye (Fig. 162, *a*).¹ The flap thus formed from the soft tissues of the cheek is dissected from the upper jaw so that the canine fossa, as well as the malar process, is exposed. The inferior tarso-orbital membrane is incised along the infra-orbital margin, so that the orbital fat protrudes. The entire contents of the orbit are carefully raised from the floor of the orbit, from which the chain-saw or the wire-saw is passed around the malar process through the infra-orbital fissure (Fig. 163) and the process is thus divided. The connection between the nasal process of the upper jaw and the frontal bone is divided transversely with the chisel. The division of the palate and of the alveolar process must yet be effected. To this end the mucous-periosteal covering of the palate is incised at the alveolar process and detached from the bone to the median line of the arch of the palate. The chain-saw is introduced through the pyriform aperture, and brought into the mouth at the junction of the hard and the soft palate. Before the palatal plate is sawed through the middle incisor tooth of the corresponding side should be removed. The jaw is now attached posteriorly only to the pterygoid process and the pyramidal process of the palate bone, and above to the ethmoid bone. It is freed from these connections, the alveolar process being grasped with Langen-

¹ Known in England and the United States as Fergusson's incision.—Ed.

beck's bone-forceps and removed with slightly rocking movements.

In the large wound exposed the severed infra-orbital artery must be caught and ligated. The margins of the cutaneous wound are accurately approximated and united



FIG. 163.—The anterior surface of the upper jaw exposed for resection: the maxillary processes are already divided.

by suture. If it has been possible to preserve the mucous covering of the hard palate, this is united to the mucous membrane of the cheek after the jaw has been completely extirpated. The wound-cavity is in all cases tamponed with gauze. If the cavity is separated from that of the mouth by the preservation of the mucous covering of the palate, the ends of the gauze are brought out of the nose.

The various methods of resection of the upper jaw differ from one another only in the form of the cutaneous incision, the procedure upon the bone being always the same. Among various forms of cutaneous incision may be mentioned Dieffenbach's median incision, a vertical incision from the root of the nose, over the roof of the nose,



FIG. 164.—Incision for resection of the upper jaw by the method of Dieffenbach.

through the middle of the upper lip, passing down to the bone and dividing the cartilage of the nose and the upper lip. From the upper extremity of this incision a second, short incision passes to the inner canthus of the eye (Fig. 164). Velpeau divides the cheek in the form of an arch from the angle of the mouth (Fig. 162, *b*). Malgaigne

combines with Velpeau's incision median division of the upper lip. The incisions should afford convenient access to the jaw, with conservation of the nerves, the vessels, and of Steno's duct, and, finally, they should yield favorable cosmetic results. All these requirements are best met by Weber's incision.

Temporary resection of the upper jaw (Langenbeck's), by which the latter, in conjunction with the skin, is freed from its attachments, and after completion of the operation is restored to its original position, is effected through a tongue-shaped flap whose base corresponds with a line uniting the root of the nose and the lower extremity of the nasal ala of the same side. The flap extends externally beyond the malar process.

The incisions at all points extend down to the bone. The attachment of the masseter is separated from the malar bone, and a pointed saw is introduced into the pterygopalatine fossa and through the sphenopalatine foramen into the nose. The point of the saw will be in the pharynx. The upper jaw is now sawed through in a line corresponding with the lower cutaneous incision above the alveolar process into the pyriform aperture.

The inferior wall of the orbit is exposed, and the malar bone is sawed through at first at its middle, and then from the infra-orbital fissure at its frontal process. If the orbital plate and the nasal process of the malar bone are divided, the upper jaw may be separated at its inner attachment, and, in connection with the overlying soft parts, may be reflected upon the nose.

Partial resection of the upper jaw is undertaken through the alveolar process for the removal of circumscribed new-growths (epulis); then, through the palatal process (Gussenbauer), in order to gain access to the base of the skull. The mucous-periosteal covering of the palate is divided in the middle line throughout its entire length, and is then reflected to either side to the alveolar process. With the aid of chisel and mallet the palatal process of the upper jaw and the palate bone, together with the

lower portion of the vomer, are removed, when both nasal cavities and the base of the skull will be rendered adequately accessible for the extirpation of tumors of the nasopharynx.

Resection of the Lower Jaw.—Upon either side of the body of the lower jaw there passes upward a ramus which articulates through its upper extremity with the glenoid cavity of the temporal bone. A second process arising from the upper extremity of the ramus is the coronoid, which serves for the attachment of the tendon of the temporal muscle. The external surface of the ramus of the lower jaw is covered by the masseter muscle, the inner by the internal pterygoid. Both of these muscles are attached at the angle of the jaw. The entrance into the inferior dental canal is marked upon the inner aspect of the ramus of the lower jaw by a bony process. A depression passing from this opening on the inner aspect of the jaw obliquely forward and downward to the chin serves for the attachment of the mylohyoid muscle.

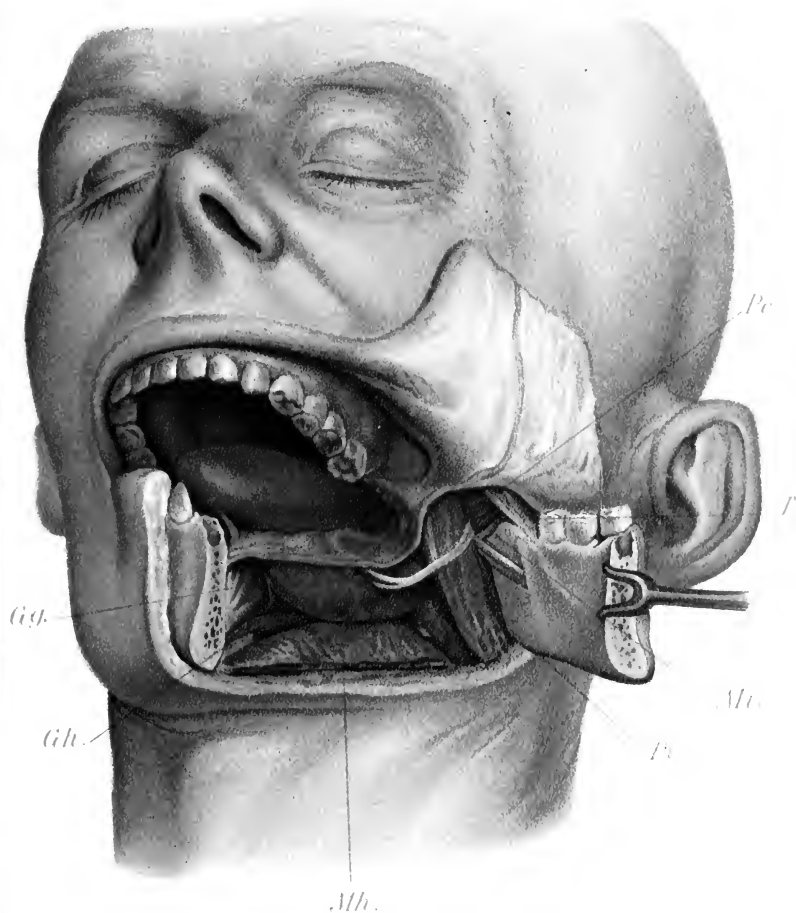
Usually resection of only one-half the lower jaw is necessary. To this end the bone is divided with the saw vertically in the middle line, its body denuded upon its outer and inner aspects, and, after division of the tendon of the temporal muscle, freed at its articulation with the temporal bone. In performing total resection of the lower jaw the bone is likewise first divided in the median line, when the two halves are separately detached. Tumors, as well as necrosis, furnish the indication for the performance of resection of the lower jaw.

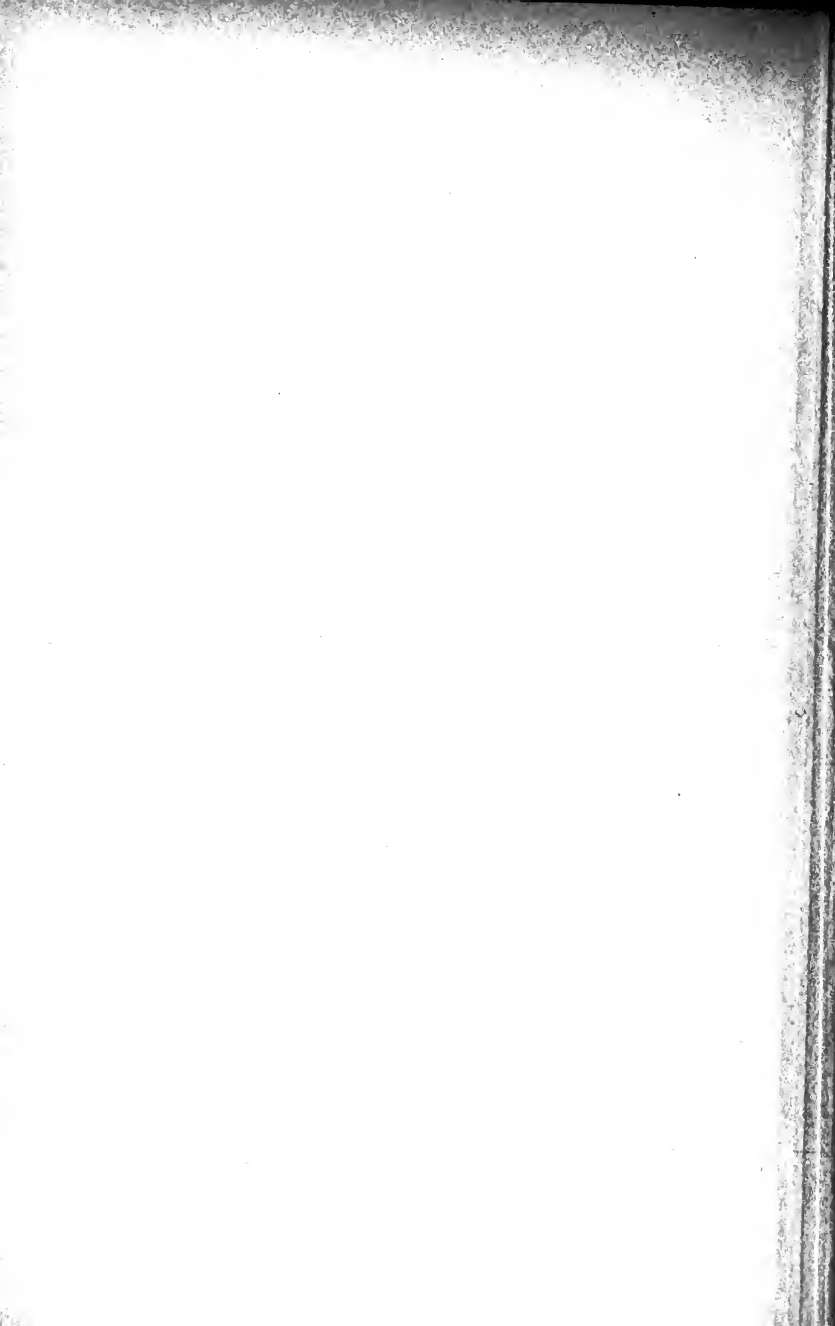
Steps of the Operation.—The patient is placed upon the table with the upper portion of the body elevated. A cutaneous incision is made vertically through the middle of the lower lip down to the chin, and from here at an oblique angle it is directed outward in the line of the border of the lower jaw to its angle. The incision at all points penetrates to the bone. The soft parts are dissected from the external surface of the bone, and the mucous membrane of the cheek is incised along its line

Plate 18.—Resection of the Lower Jaw.

The lower jaw is divided with the saw in the middle line and rotated outward. On the floor of the mouth there is visible the mylohyoid muscle overlying the sublingual gland and the lingual nerve. The internal pterygoid muscle (*Pi*) is partially detached from the jaw. Surrounding the neck of the jaw is the external pterygoid muscle (*Pe*) with the internal maxillary artery (*Mi*). The attachment of the temporal muscle (*T*) to the coronoid process is preserved: (*Gg*) genioglossus muscle; (*Gh*) geniohyoid muscle.

of reflection upon the alveolar process of the jaw. Through the cutaneous incision the soft parts are to be freed also from the posterior surface of the body of the jaw. After division of the mylohyoid muscle the mucous membrane is incised, and the buccal cavity is opened. From the inner side of the chin the origin of the genioglossus and the geniohyoid muscles of the corresponding side are freed with the knife close to the bone. After extraction of the inner incisor tooth the chain-saw or the wire-saw may be passed around the exposed bone, and the division is to be effected near the middle line in a vertical direction (Fig. 165). The operator grasps the denuded half of the jaw, and while he dislocates the bone in abduction, divides with scissors the attachments of the masseter and pterygoid muscles at the angle of the jaw. It is now an easy matter to detach by blunt dissection the soft parts on the inner and outer sides of the ramus of the jaw. While the abducted half of the bone is rotated outward, the operator divides with scissors the vessels and nerves that enter the inferior dental canal, as well as the external pterygoid muscle at its attachment to the articular process (Plate 18). After the tendon of the temporal muscle also has been divided, and after the head of the lower jaw is forced out of the glenoid fossa, the capsule of the joint is detached from the lower jaw, when the bone is freed from all its attachments. The mucous membrane of the cheek is united by suture with that of the floor of the mouth, and the wound in the skin also is closed by suture.





Temporary Resection of the Lower Jaw.—Simple division of the body of the lower jaw is undertaken when it is desired to render accessible the floor of the mouth, the palatine arch, the tongue, the upper portions of the pharynx, and the base of the brain (resection of the third

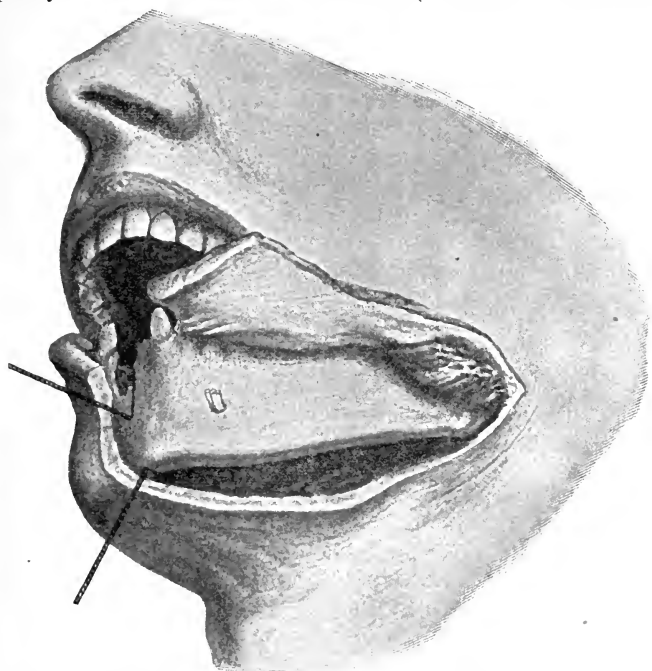


FIG. 165.—Resection of the lower jaw. The lower jaw exposed by detachment of the soft parts; the chain-saw divides the jaw in the median sagittal plane.

division of the trigeminus by the operation of Mikulicz) for purposes of surgical intervention. The division is made either in the middle line through the chin (Sédillot) or laterally (Langenbeck). The bone is sawed through or is divided with the chisel either in a linear manner or in the form of a step.

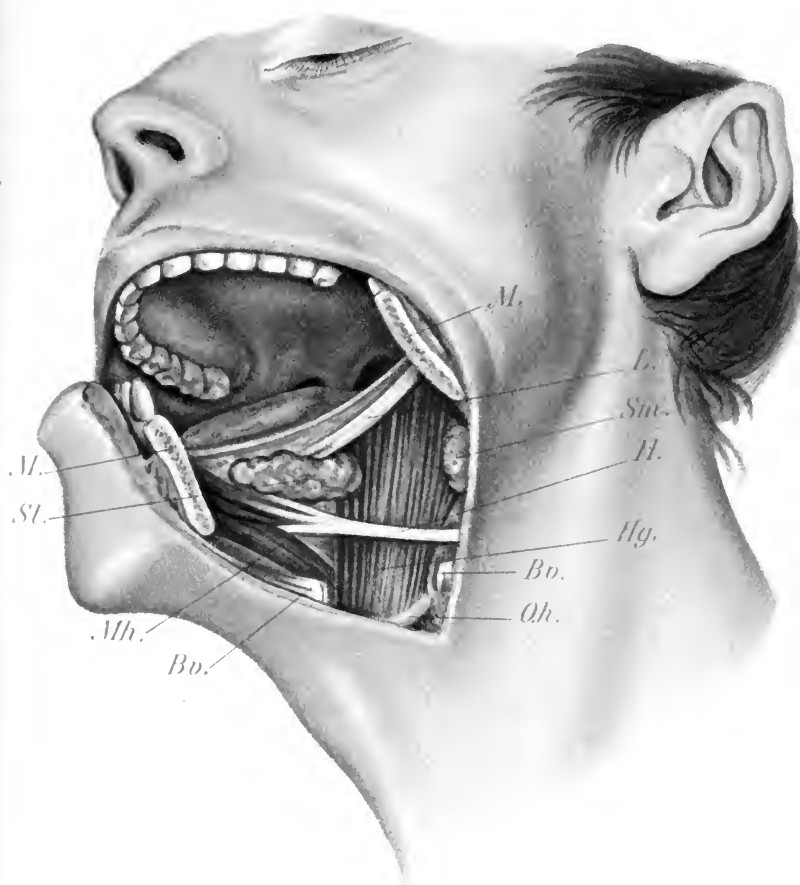
Plate 19.—Lateral Temporary Division of the Ramus of the Jaw by the Method of Langenbeck.

The wound is made to gape by separation of the segments of the jaw: *M*, sawed surfaces of the ramus of the jaw; *Oh*, hyoid bone; *Bv*, digastric muscle, with its tendon divided; *Mh*, mylohyoid muscle; *Hg*, hyoglossus muscle; *H*, hypoglossal nerve; *L*, lingual nerve; *Sm*, submaxillary gland; *Sl*, sublingual gland.

Mode of Operation.—The lower lip is divided in the median line to a point below the chin. From the lower extremity of the incision a sharp-pointed knife is passed along the posterior surface of the bone and brought out at the frenum of the tongue. After extraction of the middle incisor tooth a chain-saw or a wire-saw is passed around the bone, which is divided in a linear direction parallel with the cutaneous incision. By means of retractors the cut surfaces of the bone are separated widely, when the structures of the floor of the mouth, the sublingual gland, and the tongue itself are rendered sufficiently accessible (Fig. 166).

The posterior portion of the tongue, the palatoglossal arch, the pillars of the fauces, and the wall of the pharynx are better reached through *lateral temporary division of the ramus of the jaw*, as recommended by Langenbeck (Plate 19). The cutaneous incision passes vertically downward from the angle of the mouth to the level of the larynx. The general course of the operation corresponds with that of median division. In both instances, after completion of the operation, the divided halves of the jaw are reunited with metallic sutures. The cutaneous wound is closed with interrupted sutures.

Resection of the Lower Jaw in its Continuity.—For the removal of portions of the lower jaw in its continuity the cutaneous incision is made down to the bone at its margin. The soft tissues are detached from the outer and inner surfaces of the jaw, until the mucous membrane of the lip, as well as that of the floor of the mouth, is divided close to the bone. At the two points through which the jaw is to be sawed a tooth is withdrawn, and





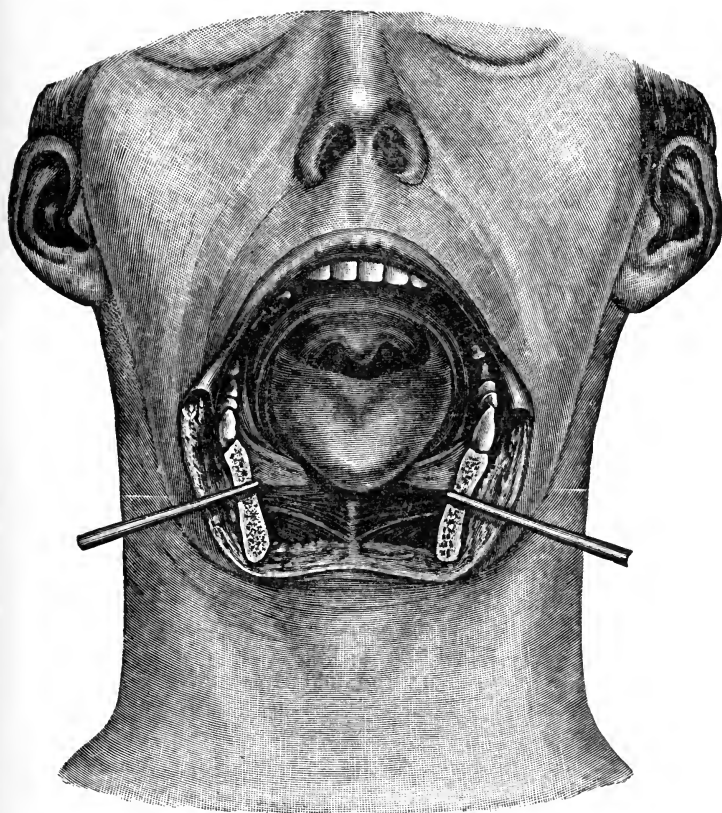


FIG. 166.—Median temporary division of the lower jaw by the method of Sédillot.

the segment of bone of determined size is removed with the chain-saw. In similar manner the middle portion of the jaw is removed. In addition to the incision at the margin of the bone, it is recommended that the lower lip in this situation be divided vertically in the middle line in such a manner that an incision of the following form results: \perp . After resection of the middle portion the stumps of the genioglossus muscles, separated from the chin, must be fixed in the cutaneous wound by suture, so that the tongue thus deprived of its attachment to the chin does not fall backward, a contingency not unattended with danger.

Operations on the Tongue.—Extirpation of tumors of the tongue are atypical procedures that are not carried out according to generally applicable rules. It is of the greatest importance that the removal of the tumor be effected through healthy tissue, and that the wound-defect be so made that union through suture or closure of the wound with healthy tongue-substance is possible. The preliminary operations performed for the purpose of facilitating total extirpation of the tongue and rendering the floor of the mouth more convenient of access have already been considered in part (temporary resection of the lower jaw).

In performing operations upon the tongue the patient is placed upon the table with the upper part of the body elevated. The neck is stretched and the head is fixed in this position. The mouth is held open with a suitable speculum or gag. The tongue is grasped with a strong silk ligature passed through its structure and drawn forward.

Circumscribed tumors at the margin of the tongue are excised in the form of a wedge through the mouth from healthy tissue with the scalpel or with scissors. The wound can be closed by linear approximation through deep and superficial sutures.

In advance of extirpation of half or the whole of the tongue ligation of the lingual artery upon one or both sides is undertaken to prevent hemorrhage.

If the extirpation is to be effected through the posterior portion of the tongue, or if together with the whole tongue the floor of the mouth and the sublingual glands are also to be removed, the field of operation is rendered more conveniently accessible by preliminary procedures.

These preliminary operations consist in :

1. Division of the cheek from the angle of the mouth ;
2. Submental incision (Regnoli-Billroth) ;
3. Temporary division of the lower jaw :
 - (a) In the middle line (Sédillot) ;
 - (b) Through the ramus of the jaw at a point corresponding with the first molar tooth (Langenbeck).

Division of the cheek in a horizontal direction from the angle of the mouth renders the operation more convenient, inasmuch as the field of operation is made roomier, and it can also be better illuminated. After the operation on the tongue has been completed the incision in the cheek can be united by suture.

Submental removal of the tongue, first performed by Regnoli of Pisa, is effected through a semilunar incision made upon the neck along the ramus of the lower jaw. Regnoli conjoined with this arched incision a second, vertical incision passing from the chin to the middle of the hyoid bone. Billroth made only the simple arched incision. Access is gained to the inner side of the ramus of the jaw, the attachments of the mylohyoid muscle are separated laterally, and those of the genioglossus, geniohyoid, and digastric muscles in the middle, and the mucous membrane of the buccal cavity is opened throughout the entire extent of the incision. The tip of the tongue is caught with a thread and drawn through the wound. By these means the structures of the floor of the mouth, as well as the tongue down to its base, are conveniently accessible for operative attack (Fig. 167).

Temporary resection of the lower jaw is effected in accordance with the rules laid down on page 219. The divided portions of the lower jaw are held apart by means

of sharp hooks, in consequence of which the field of operation is rendered more extensive. The division of the lower jaw may be linear, or, to facilitate approximation in suturing the bone, it may be made in steps.

In the presence of extensive disease of the tongue Koehler effects extirpation of the organ from the base.

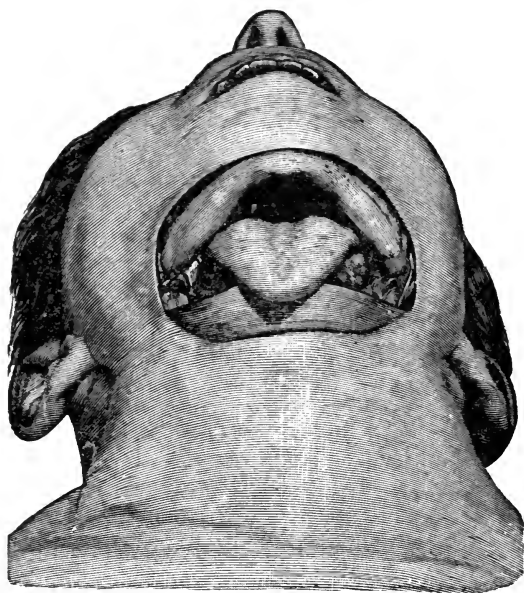


FIG. 167.—Submental exposure of the tongue by the method of Billroth.

He first performs preliminary tracheotomy. The cutaneous incision passes from the mastoid process along the anterior border of the sternomastoid muscle to the level of the hyoid bone, and from this point, in the furrow between the floor of the mouth and the neck, forward, to end in the median line at the chin (Fig. 168). The flap thus outlined is reflected back, when, after ligation of

the facial and lingual arteries, the submaxillary glands are removed. The buccal cavity is opened through the mylohyoid muscle, and the mucous membrane detached from the lower jaw. The tongue must yet be separated

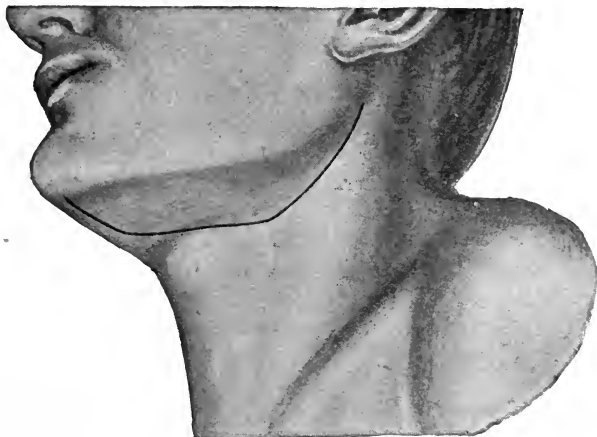


FIG. 168.—Incision for extirpation of the tongue by the method of Kocher.

from the hyoid bone, after which the whole organ can be brought forward and divided through healthy structure.

Tonsillotomy.—Amputation of hypertrophied tonsils (tonsillotomy) is undertaken with the free hand, with the blunt-pointed knife (Muzeux), or with the guillotine instrument of Fahnenstock. In the first instance the tonsil is grasped with a tenaculum forceps, drawn out of its niche, and amputated by sawing movements, from below upward, of a blunt-pointed knife (Bell's) which is curved upon the flat.

The tonsillotome of Fahnenstock facilitates rapidity in operation. The ring at the lower extremity of the instrument is for the thumb, and the ring on each side for the index-finger and the middle finger of the operating hand. While the thumb and fingers are approximated, the ring-

shaped knife advances, while, at the same time, a harpoon is projected in the opposite direction (Fig. 169, *a*, *b*).

In the performance of tonsillotomy the patient is seated on a chair with his face toward the light. The head is bent backward and the mouth is widely opened. The operator sits in front of the patient, and introduces the closed tonsillotome with the right hand, while with the left, with the aid of a spatula, he depresses the tongue upon the floor of the mouth. The tonsillotome is so introduced that the harpoon is directed in the median plane. After the ring is applied over the tonsil and slightly pressed against the arch of the palate, the tonsil

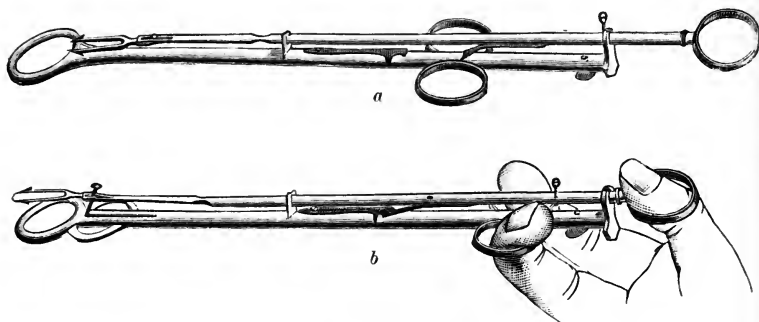


FIG. 169.—Fahnenstock's tonsillotome.

is amputated by means of vigorous pressure with the thumb and finger (Fig. 170). If the right tonsil is operated upon, either the hands must be crossed or the tonsillotome must be guided by the left hand.

In the performance of tonsillotomy in the manner described there is no danger of profuse secondary hemorrhage. Only if the incision is made more deeply and reaches the plane of the posterior capsule of the tonsil may the hemorrhage be profuse. There is no danger of injuring the internal carotid. The most reliable method of controlling the hemorrhage is by uniting the wound by deep sutures.

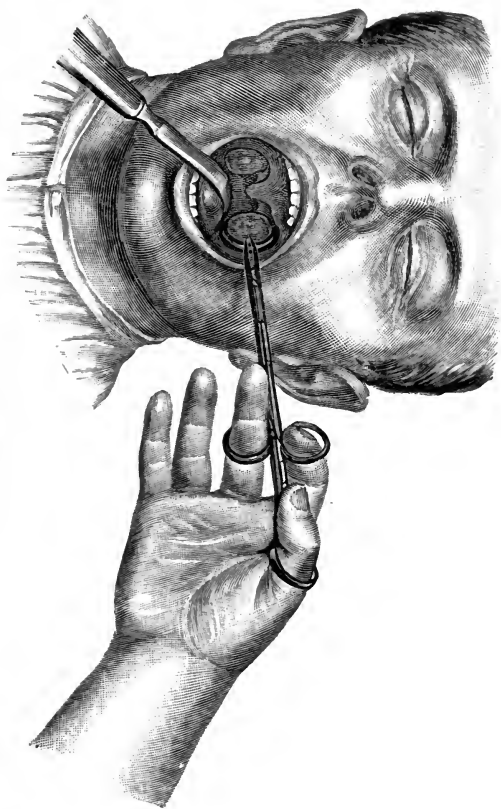


FIG. 170.—Tonsillotomy.

Plastic Operations.—Plastic operations include those accessory operations by means of which existing wound-defects are covered with integument, as well as such procedures as are intended for the correction of congenital or acquired deformity. In the first category belongs, for instance, the formation of pedunculated flaps for the closure of defects left by wounds; in the latter, the operation for harelip, rhinoplasty, blepharoplasty, etc.

In covering wound-defects the adjacent skin is drawn over either directly or after being freed by incisions and attached in place. In other cases flaps taken from neighboring structures must be separated from the subjacent tissues, and either displaced laterally or rotated about their base, in order that they may be brought in apposition with the defect, and fixed in place.

A triangular defect that is not too large is covered directly by means of deep sutures parallel to the base, and linear union is thus effected. (Linear union after wedge-shaped excision of the lower lip is illustrated in Figs. 171 and 172.) If the defect be greater, rhomboid flaps symmetrically situated on either side may be drawn toward the middle line to cover the defect (Dieffenbach, Figs. 173 and 174). In place of the rhomboid flap an arched incision passing from the base of the defect on either side may outline a portion of adjacent skin, which is brought over the defect and attached in place. Quadrilateral or oval defects may be covered by one or two symmetrically formed flaps taken from the immediate neighborhood (cheiloplasty by the method of Bruns, or by that of Langenbeck, Figs. 175 and 176) of the defect.

The flap is made to correspond in shape with that of the defect, though somewhat larger. These methods, in accordance with which the flaps are obtained from the immediate neighborhood of the defect, stand in contradistinction with that in which a pedunculated flap belonging to a remote portion of the body remains attached in

WEDGE-SHAPED INCISION OF THE LOWER LIP. LINEAR UNION.



FIG. 171.—Showing the defect in the soft parts.

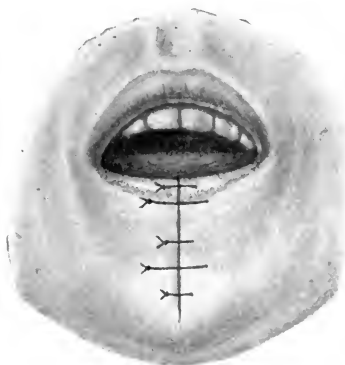


FIG. 172.—Showing the defect united by linear suture.

CHEILOPLASTY (DIEFFENBACH).

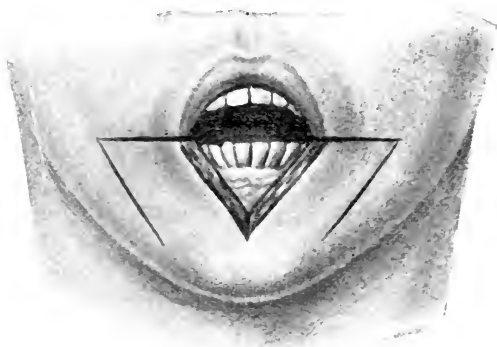


FIG. 173.—Triangular defect in the lower lip with contiguous rhomboid flaps.

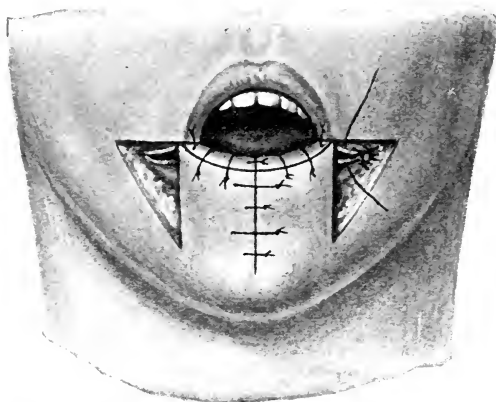


FIG. 174.—The flaps approximated by displacement toward the middle line: suture.

its original situation through the pedicle until the flap has healed in the defect (rhinoplasty by means of a flap removed from the arm, according to the method of Tagliacozzi).

Another method for covering in deficiencies by means of skin removed from remote portions of the body con-

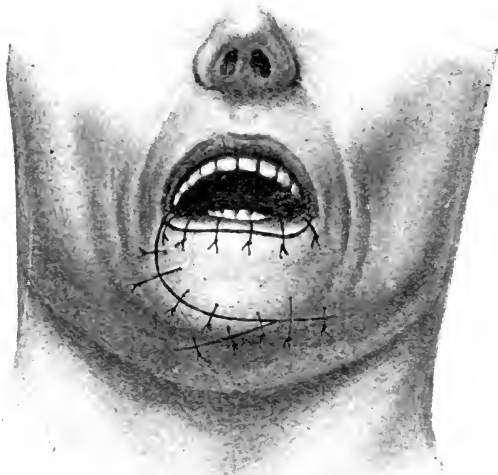


CHEILOPLASTY BY THE METHOD OF LANGENBECK.

FIG. 175.—Oval defect in the lower lip: outline of the flap.

sists in the formation of a bridge-shaped flap, beneath which the part to be covered is pushed and fixed, so that wound-surface comes to lie in apposition with wound-surface. After the flap has united it is detached from the subjacent structures by transverse division of its extremities. Finally, flaps completely separated from their attachments, that are not pedunculated, may be implanted and

made to heal upon wound-surfaces (Reverdin, Thiersch). Thiersch cuts with a broad knife large and small flaps of epidermis which are placed close together upon a freshened wound-surface, preferably like shingles upon a roof. Krause has recently applied large unpedunculated flaps, removed from the entire thickness of the skin, upon recent wound-surfaces free from hemorrhage.



CHEILOPLASTY BY THE METHOD OF LANGENBECK.

FIG. 176.—The detached flap is placed in the defect and there sutured: the spur is united with the lower border; the free border of the lip is formed from the mucous membrane of the cheek and what is left of the lower lip.

In the presence of extensive defects after extirpation of the entire lower lip the integument of the chin and of the submental region may advantageously be utilized in the form of a bridge-like flap to cover the deficiency (Morgan, Regnier). An incision parallel to the lower border of the defect is made below the chin. The dis-

CHEILOPLASTY BY THE METHOD OF MORGAN.



FIG. 177.—A bridge-shaped flap from the skin of the chin.

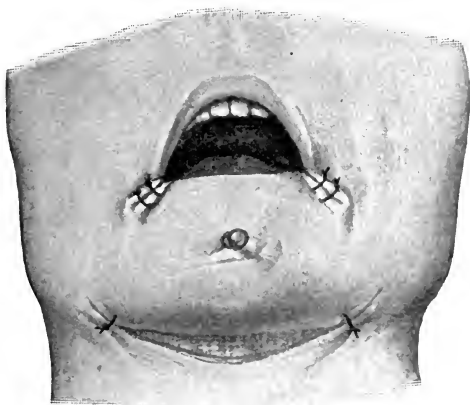


FIG. 178.—The cutaneous flap is drawn over the defect and fastened to the lower jaw by a peg.

tance of the incision from the margin of the defect should slightly exceed the height of the defect. The bridge thus formed is dissected from the subjacent tissues, and, like a visor, is pushed upward, fixed in the lower jaw by means of a peg, and fitted into the defect (Figs. 177 and 178).

Special Forms of Plastic Operations.—*Rhinoplasty.*—Plastic restoration of the nose. Total or partial rhinoplasty may be undertaken, accordingly as total or partial restoration of the nose may be required.

Formation of a Nose from the Skin of the Forehead.—The operation consists essentially in grafting upon the freshened margins of the defect in the nose an approxi-



FIG. 179.

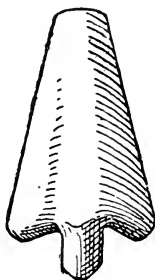


FIG. 180.

Model for rhinoplasty.

mately triangular flap from the forehead, from whose base the nasal alæ and the septum are formed. Through its apex the flap retains its connection with the skin at the root of the nose. After the defect has been freshened the size of the flap to be formed is determined by measurement, a tentative flap being first made of adhesive plaster or of leather and fitted to the deficiency. After the proper shape and size have been determined the model is spread upon the forehead and the actual flap is outlined about this. The triangular flap thus formed lies obliquely upon the forehead, with its apex directed toward the supra-orbital margin. The one side of the frontal flap is

continuous with one side of the freshened surface of the triangular defect in the nose. The flap, together with the periosteum, is detached from the subjacent structures, rotated at an angle of about 180° , and placed over the defect. The middle segment of the base of the flap, folded longitudinally and fixed by sutures, forms the septum. The lateral portions of the flap are reflected so that wound-surfaces are brought in apposition and nasal alæ are formed on either side (Figs. 179 and 180). The nose thus formed is fitted into the defect and fixed in place by sutures. The posterior extremities of the nasal alæ and the septum are to be attached to the freshened surface of

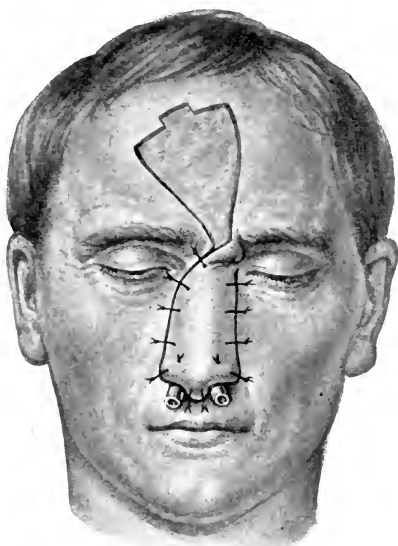


FIG. 181.—Total rhinoplasty from the skin of the forehead.

the cheek and the upper lip, when the lateral margins are to be united with the lateral portions of the defect. The defect in the forehead is reduced by means of silk sutures

before the formation of the nasal alæ and the septum. The defect still remaining in the middle is permitted to close by granulation, or it is covered with Thiersch grafts. In the newly formed nasal orifices small rubber tubes are introduced (Fig. 181). The disfiguring fold at the root of the nose corresponding to the point of reflection of the flap can be removed by excision at a second sitting after healing has taken place.

Numerous procedures have the object of providing the newly formed nose with a strong support in order that disfiguring sinking in of the tegumentary nose may be averted. Thiersch first makes a quadrangular flap on either side from the contiguous skin of the cheek with its base toward the middle line. Both flaps are united in the middle line over the defect in the nose, with the wound-surface outward. Over this is then placed the flap from the forehead made in the typical manner. The wound-surfaces are covered by transplantation.

König makes a vertical, band-like flap from the soft tissues and bone of the forehead with its base at the root of the nose. The cortical structure of the frontal bone, which is chiseled away throughout the extent of the flap, retains its attachment to the latter. The tegumentary-ossaceous flap is reflected downward over the nose, so that its wound-surface is directed forward. Over this the flap of soft tissues is formed from the forehead in the usual manner.¹

Schimmelbusch, likewise, forms the nose upon osteoplastic principles; a triangular, pedunculated flap, with its apex at the root of the nose and its base at the margin of the hair, is outlined by an incision and is chiseled away together with the cortical layer of the frontal bone. By displacement of the flap the defect in the forehead is covered, and the tegumentary osseous flap is permitted to undergo granulation. After from four to eight weeks,

¹ In saddle-nose an artificial bridge can be made of gold or platinum, and this bridge is slipped in place through an incision which is subsequently sutured.—ED.

FORMATION OF A NASAL ALA FROM THE SKIN OF THE CHEEK.



FIG. 182.—Defect and outlines of the flap.

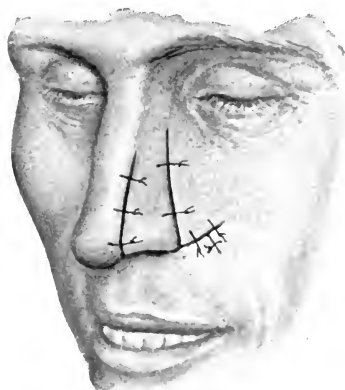
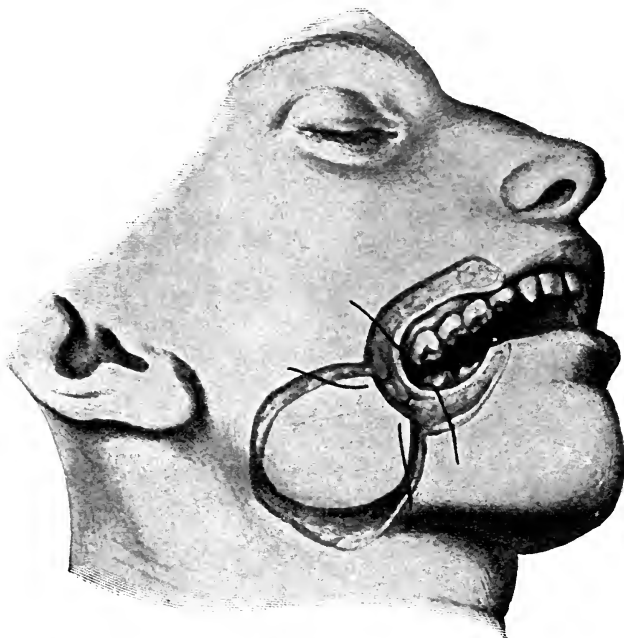


FIG. 183.—The flap is placed in the defect and there sutured.

when all necrotic tissue has been exfoliated, cicatrization of the inner surface of the flap is brought about by transplantation by the method of Thiersch. Only after the flap is covered by skin is it in a separate operation placed in the freshened defect in the nose, where it should heal



MELOPLASTY BY THE METHOD OF KRASKE-GERSUNY.

FIG. 184.—Penetrating defect in the cheek, in the immediate neighborhood of which an unpedunculated flap has been outlined.

in place. The septum is formed from the cutaneous margin of the pyriform aperture by means of two symmetrical flaps.

The last two methods (König, Schimmelbusch) may be employed advantageously in the operation for saddle-nose.

MELOPLASTY BY THE METHOD OF KRASKE-GERSUNY.

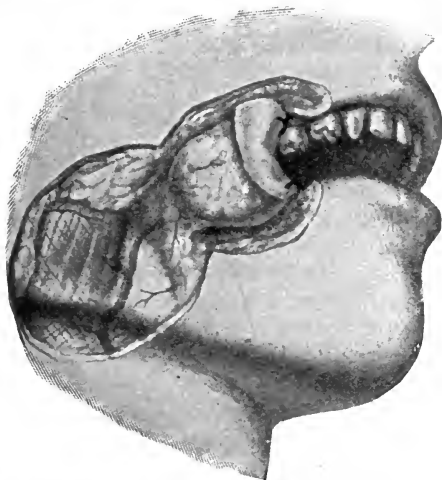


FIG. 185.—The flap is dissected over toward the defect and remains in connection with the adjacent structures only by means of the subcutaneous connective tissue.

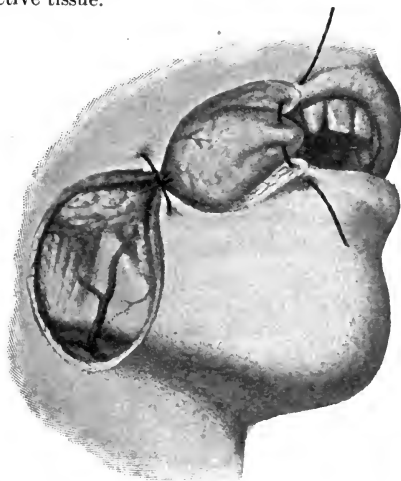


FIG. 186.—The flap, with its cutaneous surface directed toward the cavity of the mouth, is sutured in the defect.

Operation for Harelip.

NÉLATON'S METHOD.

FIG. 187.—Freshening.

FIG. 188.—Wound after adjustment of the lip.

FIG. 189.—Suture.

MALGAIGNE'S METHOD.

FIG. 190.—Freshening.

FIG. 191.—The flap on either side is dislocated downward.

FIG. 192.—Suture.

According to the method of Tagliacozzi, the skin for the formation of the nose is obtained from the forearm. The rhomboid flap at first retains its connection with the arm by means of its pedicle, and is in part sutured in the freshened defect. For this purpose it is necessary for the arm to be placed and maintained immovably in a position as close to the face as possible. Only after the flap has healed in place can the bridge that connects it with the arm be severed. The nose is then formed from the flap in the customary manner.

For *partial plastic operations upon the nose* strict rules cannot be formulated. Suitable procedures will have to be devised for the individual case from the elements for the plastic closure of defects. In the absence of the lateral wall of the nose also the flap to cover in the defect may be taken from the forehead. In the formation of a nasal ala a pedunculated flap is formed from the dorsum of the nose, and from the opposite side of the nose, or from the skin of the cheek. The pedicle of the flap is at the upper portion of the back of the nose (Figs. 182 and 183). A pedunculated flap formed from the substance of the upper lip may, by rotation, be introduced into the freshened defect of the nasal ala and there be fixed by suture. To replace an absent septum the tissues may be advantageously obtained from the upper lip.

Plastic closure of defects in the integument of the cheek (meloplasty) involving its entire thickness requires special operations. The flap ingrafted in the defect must be covered upon its inner surface with skin or mucous mem-

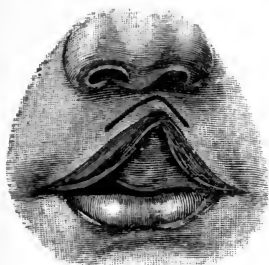


FIG. 187.

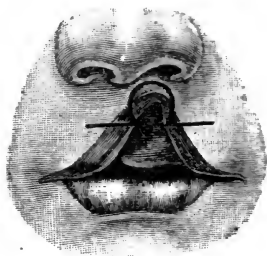


FIG. 190.

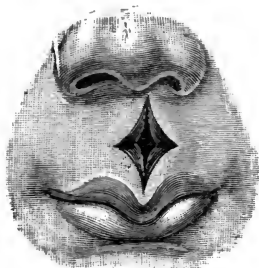


FIG. 188.

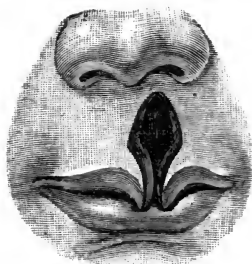


FIG. 191.

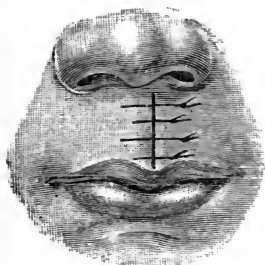


FIG. 189.

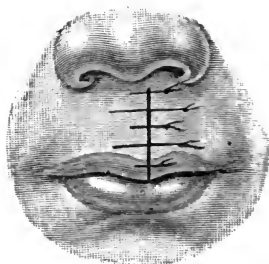


FIG. 192.

Operation for Harelip.

MIRAULT-LANGENBECK'S METHOD.

FIG. 193.—Freshening.

FIG. 194.—Wound.

FIG. 195.—Suture.

Operation for Bilateral Harelip.

FIG. 196.—Freshening.

FIG. 197.—Wound.

FIG. 198.—Suture.

brane to prevent cicatricial contraction. Wölfler obtains mucous membrane from some other part of the body and transplants it to the inner aspect of the flap. Thiersch's flaps also have been utilized for the same purpose (Ewald). Success will be more certain if, in replacing the defect in the mucous membrane, a cutaneous flap with its epidermal aspect directed toward the cavity of the mouth is fitted into the defect. Kraske incises the skin adjacent to the defect in the form of a flap, which is dissected free from its margin toward the defect and has its cutaneous surface directed toward the cavity of the mouth. Gersuny has shown that the nutrition of the flap will be sufficient also if this remains connected with the subjacent structures only by a zone of subcutaneous connective and fatty tissue. The mode of procedure is indicated in Figs. 184, 185, and 186. The outer side of the flap, as well as the defect resulting from the plastic operation, can be covered by plastic flaps or by transplantation by the method of Thiersch. Czerny employs a long flap made from the integument of the neck, which is folded and lies in the defect like a double flap. The flap is twice as long as the defect to be covered.

Israel forms also a long flap from the integument of the neck, whose extremity is sutured in the defect in such a manner that the cutaneous surface is directed toward the buccal cavity. After the flap has healed in place it is severed at its point of insertion and the free posterior portion is folded, and, with wound-surface applied to wound-surface, placed upon the already healed portion of the flap.

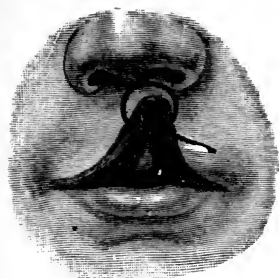


FIG. 193.

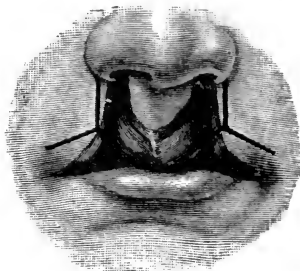


FIG. 196.

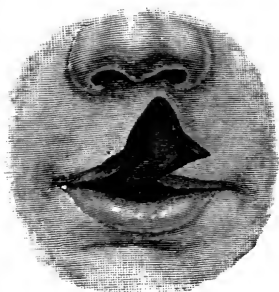


FIG. 194.

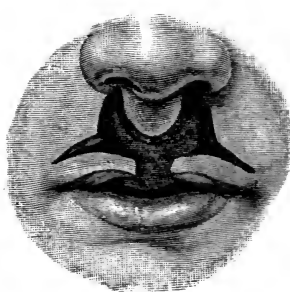


FIG. 197.

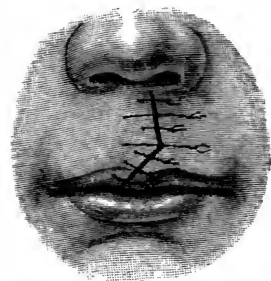


FIG. 195.

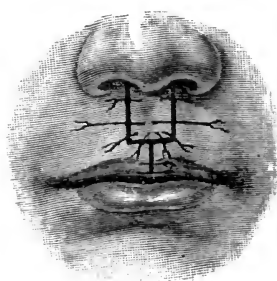


FIG. 198.

The flap closing in the defect is thus double, with its cutaneous surfaces directed on the one side toward the mouth, and on the other side toward the exterior.

Operation for Harelip.—Nélaton's procedure, intended for the correction of incomplete harelip, consists in division of the upper lip above and parallel with the defect. The margin of the defect is drawn downward and the rhombic wound is united in a linear manner at right

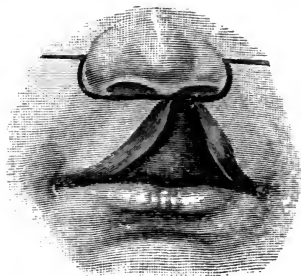


FIG. 199.—Incisions for the relief of tension when the fissure in the lip is a large one.

angles to the transverse fissure of the mouth (Figs. 187, 188, and 189). Malgaigne forms a flap upon either side from the free border of the lip bounding the defect and removes the angle of the defect. The flaps are deflected downward and united with each other (Figs. 190, 191, 192). A modification of this method constitutes the operation of Mirault-Langenbeck. From one of the margins of the defect a Malgaigne flap is formed in typical manner. The second margin of the defect is freshened in a bevelled manner, and the red border of the lip is removed at the angle of the defect. After union has been effected the flap constitutes the free border of the lip (Figs. 193, 194, and 195).

In cases of bilateral harelip the middle segment, as well as both lateral margins of the defect, must be freshened. A Malgaigne flap is formed on either side, which is cut through at its apex. The flaps are displaced down-

ward and united with one another below the middle segment. The margin of the defect on either side is brought in apposition with the corresponding freshened edge of the middle segment, with which it is united (Figs. 196, 197, and 198).

If the fissure in the lip gapes so widely that its margins cannot be brought in apposition, incisions for the relief of tension are made at the nasal alæ to give mobility to the margins of the fissure (Fig. 199).

If the middle segment is especially prominent, plastic closure of the double fissure in the lip is to be effected only after depression of the intermaxillary bone. To this end the mucous membrane at the lower free border of the septum is divided and separated from the vomer on either side. The vomer is divided throughout its entire height with a single stroke of the scissors, when the intermaxillary bone can be readily pushed into place by pressure from before backward.

Staphylorrhaphy and Uranoplasty.—*Staphylorrhaphy*, plastic closure of congenital defects of the soft palate, consists in freshening of the margins of the defect and their union by suture. The operation is performed with the patient either in the upright posture or with the head dependent. The margins of the defect are grasped individually with forceps and the freshening is effected with a small sharp-pointed knife, and union is established by means of small, heavily curved needles. If the margins of the defect can be brought together only with great tension, it is recommended that freeing incisions be made on either side of the veil of the palate.

Plastic closure of defects of the hard palate (*uranoplasty*) is effected in three steps. The first consists in freshening the margins of the defect and the formation of a bridge-like flap on either side in such a manner that an incision is made through the mucous membrane on each side down to the bone, parallel with the margin of the defect, at the alveolar border of the palate, reaching from the last molar to the outer incisor tooth. In the second step of the operation the flap thus outlined is rendered mobile, the mucous-periosteal covering of the palate being separated from the bone by means of a small raspatory introduced through the outer incision. To render mobile

the soft palate, its attachment to the palate bone is freed by means of a knife curved on the flat, so that the flaps at all points can be moved toward the middle line without tension. The last step of the operation, which consists in suture, is carried out in the middle line in the same way as in staphylorrhaphy.

To avoid undue tension upon the approximated flaps semilunar lateral freeing incisions through the veil of the palate have been recommended (Dieffenbach). Billroth dispenses with the incisions through the velum, and prefers chiselling the median plate of the pterygoid process of the sphenoid bone, by displacement of which inward relief of tension is effected. Wolff effects sufficient mobilization of the soft palate by adequate detachment of the coverings of the hard palate, so that accessory operations are unnecessary.

Operations on Nerves.—If in cases of trigeminal neuralgia conservative methods of treatment have been unattended with success, operative intervention becomes allowable. Simple division of the nerve (*neurotomy*) is unjustifiable, as experience has shown that the transverse sections of the divided nerve shortly reunite. The excision of a portion of the nerve (*neurectomy*) is more promising in this connection, although the nerve is regenerated after a somewhat longer time. Large segments of nerves, together with their smallest branches, may be removed by means of the procedure of Thiersch (excision of nerves, *neuraxairesis*). The nerve in question is exposed in a given situation, grasped transversely with a forceps-like instrument, and removed throughout a considerable extent of both its distal and its proximal course by slowly rotatory movements (a half rotation in the second, Thiersch).

First (Ophthalmic) Division of the Fifth Nerve.—The smallest of the three divisions of the trigeminal nerve enters the orbit through the sphenoidal fissure. Of the branches of the ophthalmic, only the frontal nerve is of surgical importance. It runs along the roof of the orbit, and divides into two branches: the supratrochlear, which leaves the orbit above the pulley of the superior oblique muscle to supply the skin of the upper eyelid and the

forehead; and the supra-orbital, which passes through the supra-orbital notch to the forehead.

To expose the *frontal nerve* an incision is made below the eyebrow parallel with the supra-orbital margin, dividing the skin and the tarso-orbital fascia. The contents of the orbit are carefully detached, when the trunk of the nerve becomes visible on the roof of the cavity. The branches of the nerve are looked for, grasped with the forceps, and torn out individually (Fig. 200).

Second (Superior Maxillary) Division of the Fifth Nerve.

—The supramaxillary division of the fifth nerve leaves the cranial cavity through the foramen rotundum, enters

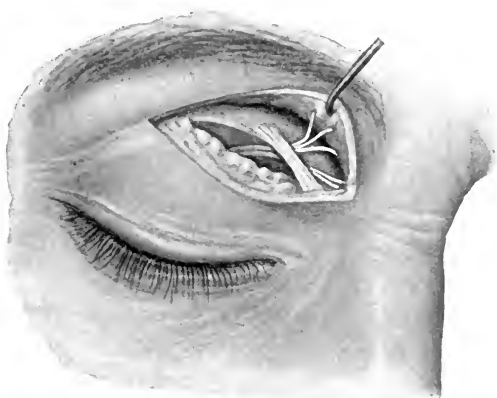


FIG. 200.—Exposure of the frontal nerve.

the sphenomaxillary fossa, and passes without change of course through the infra-orbital fissure into the infra-orbital canal on the floor of the orbit, leaving the latter through the infra-orbital foramen, to break up upon the face in a fan-shaped distribution into its various branches. The infra-orbital foramen is situated in the canine fossa, about 0.5 cm. below the middle of the infra-orbital margin.

To expose the *infra-orbital nerve* at its point of exit in the canine fossa the incision is made about 0.5 cm. below and parallel with the infra-orbital margin throughout an extent of about 4 cm. The lower margin of the wound is retracted by means of hooks. The incision through the elevator muscles of the upper lip passes down to the bone, and the periosteum is reflected downward, when the

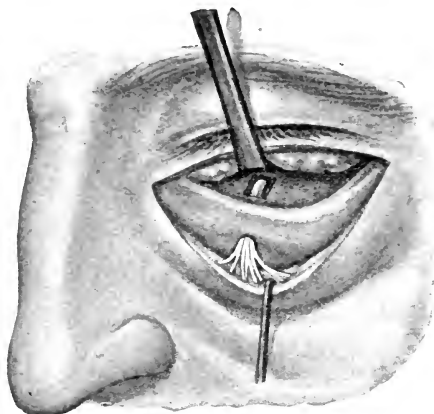


FIG. 201.—Exposure of the infra-orbital nerve.

trunk of the nerve, as it escapes from the infra-orbital foramen, as well as its radiation upon the face, comes into view. After division of the inferior tarso-orbital membrane the contents of the orbit are raised upward, when the infra-orbital canal, covered by a thin lamella of bone on the floor of the orbit, is exposed. This lamella is removed as deeply as possible, the nerve grasped, and its central extremity gradually withdrawn (Fig. 201). The peripheral portion of the nerve can be removed to its finest branches by being rolled up upon Thiersch's forceps.

If the superior maxillary nerve is to be exposed at the

base of the skull, access to it will be gained by temporary resection of the malar bone (Lossen, Braun). An incision through the integument is made, as in exposing the infra-orbital nerve (Kocher), and it is extended outward over the malar prominence. The malar bone, together with the malar process of the upper jaw and the zygomatic ridge of the sphenoid bone, is resected in such a manner that a large portion of the outer wall of the orbit is removed. The malar bone is drawn outward, if it is divided also through its temporal process, and the nerve is grasped at the foramen rotundum and extracted with Thiersch forceps.

Third (Inferior Maxillary) Division of the Fifth Nerve.

—The third division of the trigeminal nerve leaves the skull through the foramen ovale. Of the upper group of its branches only the buccinator nerve is subjected to surgical attack. This nerve burrows through the external pterygoid muscle and passes along the outer surface of the buccinator muscle to the angle of the mouth. The nerve is at times the seat of isolated neuralgia. Of the larger branches of the inferior maxillary nerve, the inferior dental and the lingual are of surgical importance. The inferior dental nerve, the largest branch of the inferior maxillary, passes downward between the internal and external pterygoid muscles. On the inner aspect of the ramus of the lower jaw it enters, with the artery of the same name, into the dental foramen and passes through the dental canal, to make its exit at the mental foramen as the mental nerve. The lingual nerve in the first part of its course passes downward with the dental nerve. At the anterior border of the internal pterygoid muscle it turns forward, and passing over the mylohyoid muscle reaches the lateral border of the tongue.

Extrabuccal Exposure of the Buccinator Nerve (E. Zuckerkandl).—A cutaneous incision is made in the direction of a line passing from the tragus to the middle of the nasolabial fold. The duct of Steno appears in the wound and is drawn downward. After division of the

masseter fascia the buccal pad of fat comes into view, and is freed from its attachments and removed. In the wound there is now visible the coronoid process of the lower jaw, with the prominent lower portion of the tendon of the temporal muscle. At the inner border of this tendon, surrounded by loose cellular tissue, lies the trunk of the buccinator nerve.

The *inferior dental nerve* may be exposed before its entrance into the dental canal, within the canal, and after its exit at the mental foramen. Prior to its entrance into the canal, at the lingula, the nerve is accessible from without (Sonnenburg's opening), as well as from within, the cavity of the mouth (Paravicini). Sonnenburg makes an incision around the angle of the lower jaw, separates the insertion of the internal pterygoid muscle from the bone, and advances along the inner surface of the ramus of the jaw to the lingula, where the nerve is grasped with a blunt hook, brought out and resected, or extracted with forceps. This method is attended with difficulties in so far as it is necessary to operate at a considerable depth; even operating upon the dependent head simplifies the procedure only in inconsiderable degree. Paravicini has recommended exposure of the nerve from the buccal cavity by separation of the internal pterygoid muscle from the inner surface of the ramus of the jaw at the lingula.

Exposure of the Inferior Dental Nerve within the Dental Canal.—The nerve is most conveniently reached by chiselling out a piece of the outer plate of the bone at the point of junction between the body and the ramus, and in this manner exposing the dental canal. An arch-shaped cutaneous incision is made at the angle of the jaw. The attachment of the masseter muscle is freed and separated from the bone in the neighborhood of the angle of the jaw by means of a raspator. In the middle of a line uniting the angle of the jaw with the last molar tooth a piece of bone as large as a lentil is gouged out of the outer wall of the jaw. After the cortical

structure has been passed profuse arterial hemorrhage from the injured inferior dental artery will indicate that the canal has been opened. With a blunt hook the nerve can be readily raised from its bed, and it is either resected, or, better, it is extracted with forceps.

The lingual nerve is most readily reached from the buccal cavity. An incision is made upon the side of the tongue at the point of reflection of the mucous membrane from the inner side of the lower jaw upon the tongue.

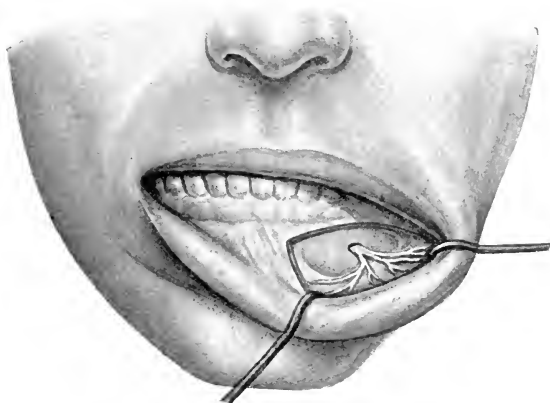


FIG. 202.—Intrabuccal exposure of the mental nerve.

The large nerve-trunk lies immediately beneath the mucous membrane. The method of Sonnenburg and that of Paravicini for exposure of the inferior dental nerve also permit access to the lingual nerve in its upper part.

The mental nerve can be made accessible at its point of exit from the lower jaw, from either within or without the buccal cavity. Extrabuccal exposure is accomplished by means of a cutaneous incision through the chin at the level of, and several centimeters external to, the incisor

tooth of the corresponding side. The incision reaches down to the bone, and the soft parts are detached from the jaw, when the nerve can be seen making its exit as a tense cord from the mental foramen. To gain access to the nerve from within the cavity of the mouth an analogous procedure is followed. The incision is made at the point of reflection of the mucous membrane from the inner surface of the lower lip upon the lower jaw (Fig. 202).

Operation for Exposure of the Second and Third Divisions of the Fifth Nerve at the Base of the Skull by the Method of Krönlein.—A semicircular flap, with its convexity downward, is formed from the tissues of the cheek, its base corresponding to the upper boundary of the zygomatic arch. The cutaneous flap is dissected upward, the temporal fascia divided transversely over the malar bone, then the zygomatic arch sawed through in advance of the articular tubercle and through the body of the bone and, with the attachment of the masseter muscle, reflected downward. The exposed coronoid process of the lower jaw is broken through and, together with the tendon of the temporal muscle, is displaced upward. The third division of the fifth nerve is reached by passing from the upper border of the external pterygoid muscle, toward the base of the skull, just behind the root of the pterygoid process, where the foramen rotundum is situated.

To reach the superior maxillary nerve, progress must be made forward through the wound to the pterygopalatine fossa, where in the depth of the depression the nerve can be grasped with a hook just after its exit from the round canal and drawn forward. In closing the wound the detached segments of bone are fixed in their original situations by means of bone-sutures and the margins of the cutaneous wound are approximated.

Exposure of the Third Division of the Fifth Nerve at the Base of the Skull.—*Retrobuccal Method of Krönlein.*—A cutaneous incision is made on the cheek from the angle of the mouth to the lobule of the ear. The buccal pad of

fat is lifted out of its bed and removed completely ; then the coronoid process is divided and dislocated upward. The lingual and inferior dental nerves are exposed and isolated on the inner aspect of the ramus of the lower jaw, and followed upward to the base of the skull, while the external pterygoid muscle is drawn to one side. Salzer forms a flap with its base downward from the tissues of the cheek and the temporal region, and extending a finger's breadth beyond the zygomatic arch. The latter is resected and, together with the skin, is reflected downward. The temporal muscle, beginning at its insertion, is freed from the bone. Progressing from the outer surface of the temporal bone toward the under surface of the sphenoid bone the foramen ovale is reached, where the nerve is divided with a tenotome having a concave edge. By the method of Mikulicz access to the trunk of the nerve is gained by temporary resection of the lower jaw just in advance of the insertion of the masseter muscle. The cutaneous incision passes from the mastoid process along the sternomastoid muscle to the cornu of the hyoid bone, and from this point in a curved direction to the anterior border of the masseter muscle.

Intracranial Operations on the Trigemini.—*Extirpation of the Gasserian Ganglion by the Method of Krause.*—A uterus-shaped flap is formed from the structures in the temporal region, with its base over the zygomatic arch. The flap is 6.5 cm. long, and its base measures 3 or 3.5 cm. Its greatest width is 5 or 5.5 cm. The incision passes down to the bone. The cranium is opened with the circular saw or with chisel and mallet in the shape and size of the cutaneous flap and the skin with the bone attached is reflected downward. The surgeon advances between the bony floor of the skull and the dura in the middle cerebral fossa to the foramen spinosum, where the trunk of the middle meningeal artery is ligated and divided. To this end the brain enclosed in dura must be carefully raised upward with a broad-bladed spatula. After extensive separation of the dura from the bone and

elevation of the brain the Gasserian ganglion comes into view, in the depth of the middle cerebral fossa, external to the dura. The ganglion is grasped transversely with Thiersch's forceps at the point where it becomes the trunk of the trigeminus, when the second and third divisions of the nerve are divided in the intracranial openings of the respective canals. The first division of the nerve will have been previously divided close to its origin from the ganglion. By rotation of the forceps the ganglion, together with a proximal portion of the trigeminus trunk, will be extracted. Doyen has endeavored to facilitate access to the ganglion by resection of the malar bone.

Operations on the Air-passages.—The air-passages may be opened through the larynx (*laryngotomy*), or through the trachea (*tracheotomy*). The incisions for opening the respiratory tract are longitudinal, and are made on the anterior aspect of the neck in the middle line. The upper and lower hyoid muscles, which cover the respiratory tract, are arranged symmetrically and meet in the middle line of the neck. Between the inner borders of these muscles (white line of the neck) access may be gained to the larynx or the trachea by merely passing through the layers of fascia and the connective-tissue space.

Opening of the Larynx (Laryngotomy).—The situation of the cartilaginous constituents of the larynx can be accurately determined from the surface of the neck by palpation. The laryngeal prominence, the edge formed by the approximation of the lateral halves of the thyroid cartilage, the arch of the cricoid cartilage, are accessible to palpation, as well as the cricothyroid membrane, which appears as a less resistant area between the thyroid and cricoid cartilages. The larynx is opened in the middle line either through the thyroid cartilage (*thyrotomy*) or through the cricothyroid membrane (*cricothyrotomy*); finally, the larynx may be divided by a median incision throughout its entire length down to the first tracheal ring (*laryngofissure*). Thyrotomy or laryngofissure is always preceded

by tracheotomy and the introduction of a tracheal cannula.

Thyrotomy is undertaken :

(1) In the presence of foreign bodies in the larynx which have become impacted and cannot be removed by endolaryngeal procedures ;

(2) In the presence of cicatricial narrowing of the larynx ;

(3) In the presence of tumors of the larynx ;

(4) As a preliminary operation in the performance of total or unilateral extirpation of the larynx.

Laryngofissure may be necessary in the extirpation of tumors when for their complete removal freer access to the interior of the larynx is required.

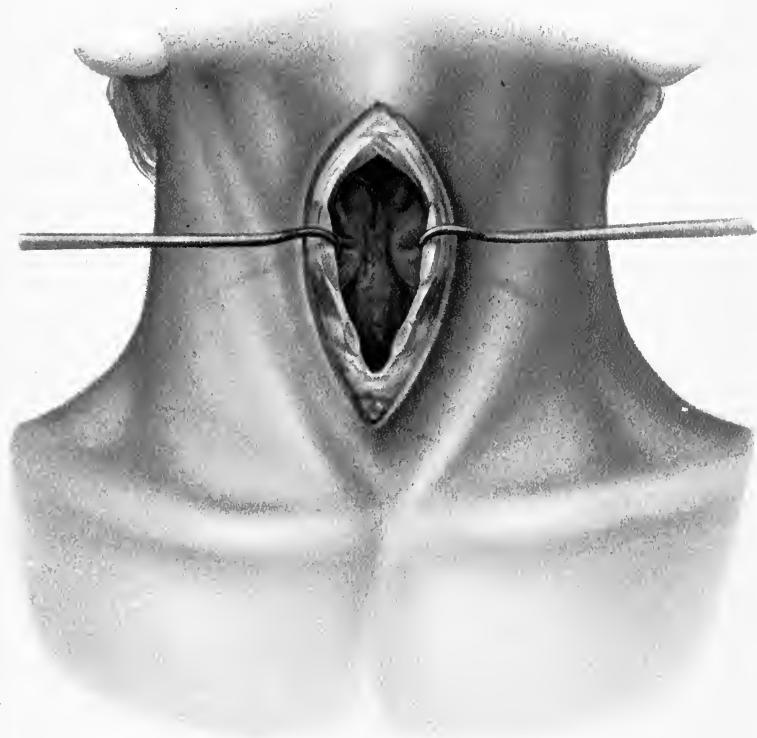
In the performance of *thyrotomy* or *laryngofissure* the patient is placed in the dorsal decubitus, with the upper portion of the body elevated, and the cervical portion of the spinal column extended. The incision is made accurately in the middle line from the hyoid bone to the cricoid cartilage. The cervical fascia is divided, the sternohyoid muscles are separated, and the thyroid cartilage is exposed. The cartilage is fixed at its lower border with a sharp hook, and a sharp-pointed knife is introduced through the cricothyroid membrane into the lumen of the larynx. Through this opening the thyroid cartilage is divided with scissors, with a blunt-pointed knife, or, if necessary, with bone-scissors, accurately in the middle line upward to the thyrohyoid membrane. The lateral halves of the divided thyroid cartilage are held apart by means of sharp tenacula, exposing the interior of the larynx to operative attack (Plate 20). In accordance with the nature of the operation, it is at times desirable to keep the larynx open during the after-treatment. Under other conditions the halves of the thyroid cartilage and the overlying skin are closed by interrupted sutures. For the first days after the operation, during the process of healing, the entrance of air into the lungs is insured through a cannula introduced into the trachea.

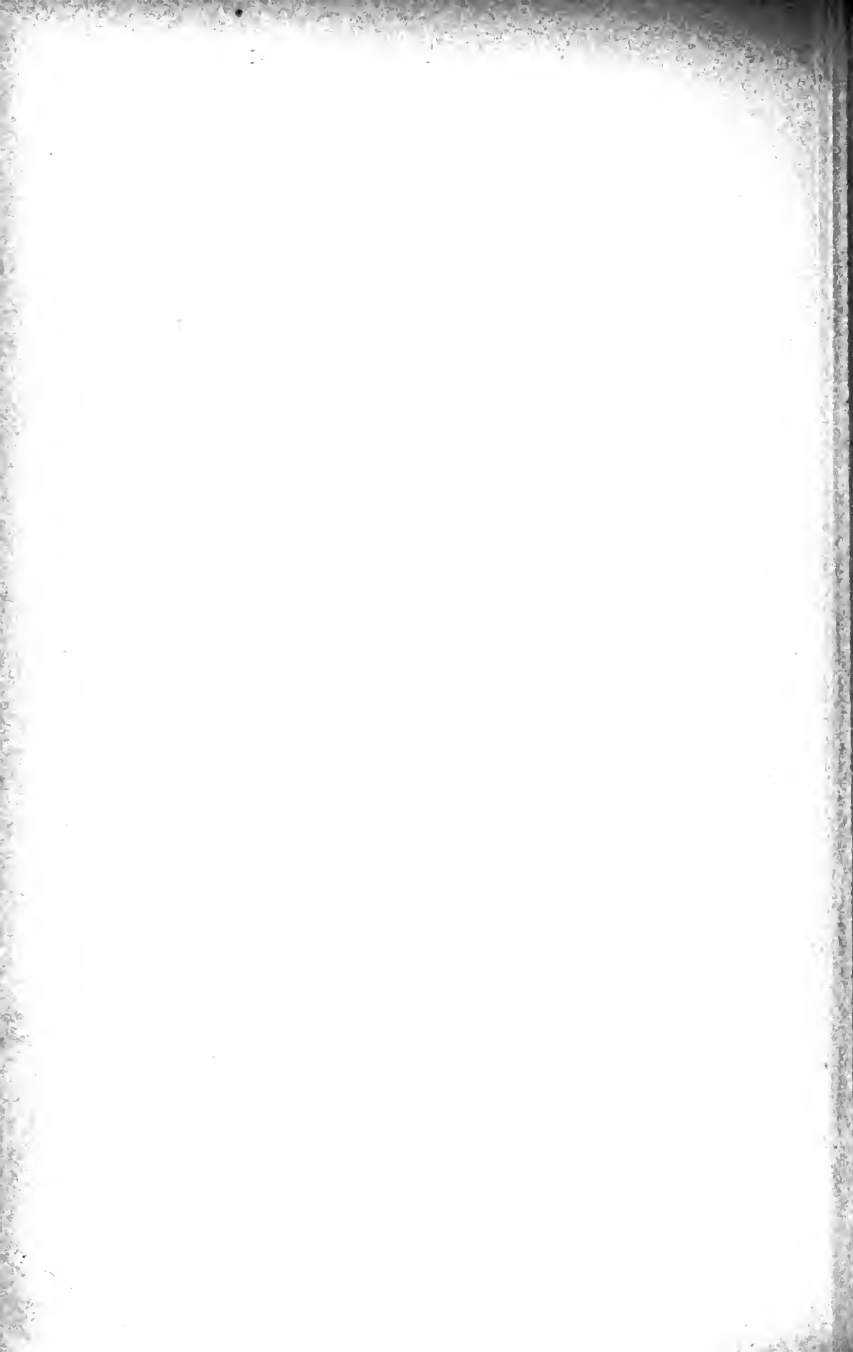
Plate 20.—Laryngofissure.

The thyrohyoid membrane, the thyroid cartilage, the cricothyroid membrane, and the cricoid cartilage are divided in the middle line.

The lateral halves of the thyroid cartilage are held apart by tenacula; the interior of the larynx, the arytenoid cartilages, the ventricular bands, and the vocal bands are exposed to view.

Cricothyrotomy, opening the larynx through the cricothyroid membrane, can, if necessary, be executed in the shortest possible time by reason of the superficial situation of the cricothyroid ligament. On this account cricothyrotomy is the operation usually employed to prevent acute suffocation following occlusion of the larynx by a foreign body, in cases of laryngospasm, etc. A short cutaneous incision is made from the middle of the prominence of the thyroid cartilage downward beyond the cricoid cartilage (Fig. 203, *b*). If delay be dangerous, the lower extremity of the cricoid cartilage may, after division of the skin, be grasped and held securely with a sharp tenaculum passed through the ligament. If the operator has convinced himself by touch with the finger as to the position of the membrane, this is cautiously incised in the middle line with a sharp-pointed knife until a sensation is conveyed through the instrument of having entered the lumen of the larynx. At once the opening in the membrane is made to gape by means of a hook inserted on either side, and, if necessary, the membrane is, further, notched. The cannula is introduced into the opening thus made and the hooks are removed from the wound. By this mode of procedure there is no loss of blood and the cannula lies so snugly within the wound as to constitute a sort of tampon. If there be sufficient time for the performance of the operation, the cutaneous incision is made longer, and the cricothyroid membrane is laid bare by careful dissection. After the subcutaneous connective tissue has been passed, the cervical fascia is divided and the cricothyroid membrane is exposed. The lower border of the cricoid cartilage is raised up by means of a simple sharp





tenaculum, which is introduced into the middle line, when the membrane is divided vertically and a cannula is introduced. If necessary, the longitudinal incision in the membrane is notched on the right and the left. Through the crucial incision thus formed the cannula is readily introduced. The latter is held in place in the wound by

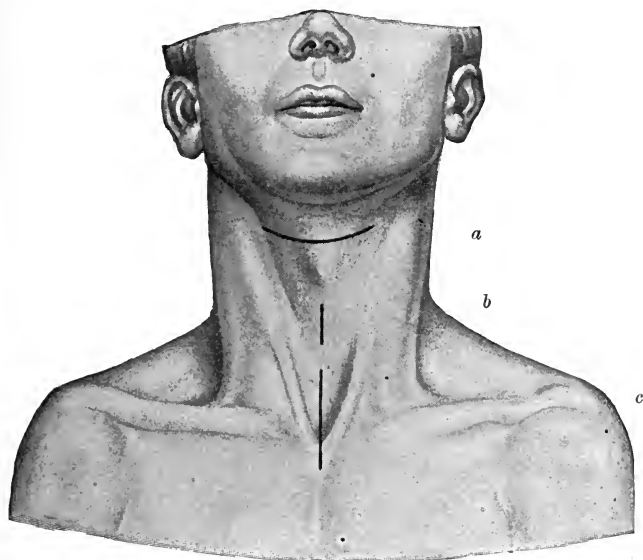


FIG. 203.—Cutaneous incisions on the neck: *a*, infrahyoid pharyngotomy; *b*, cricothyrotomy; *c*, inferior tracheotomy.

means of linen tapes attached to the shield of the cannula, and tied at the nape of the neck.

Total and Partial Extirpation of the Larynx.—*Total Extirpation of the Larynx by the Method of Billroth.*—Tracheotomy is performed a few days in advance of the operation, and a tampon-cannula is introduced. A longitudinal incision is made in the median line over the thyroid cartilage, with which is conjoined a transverse incision at the

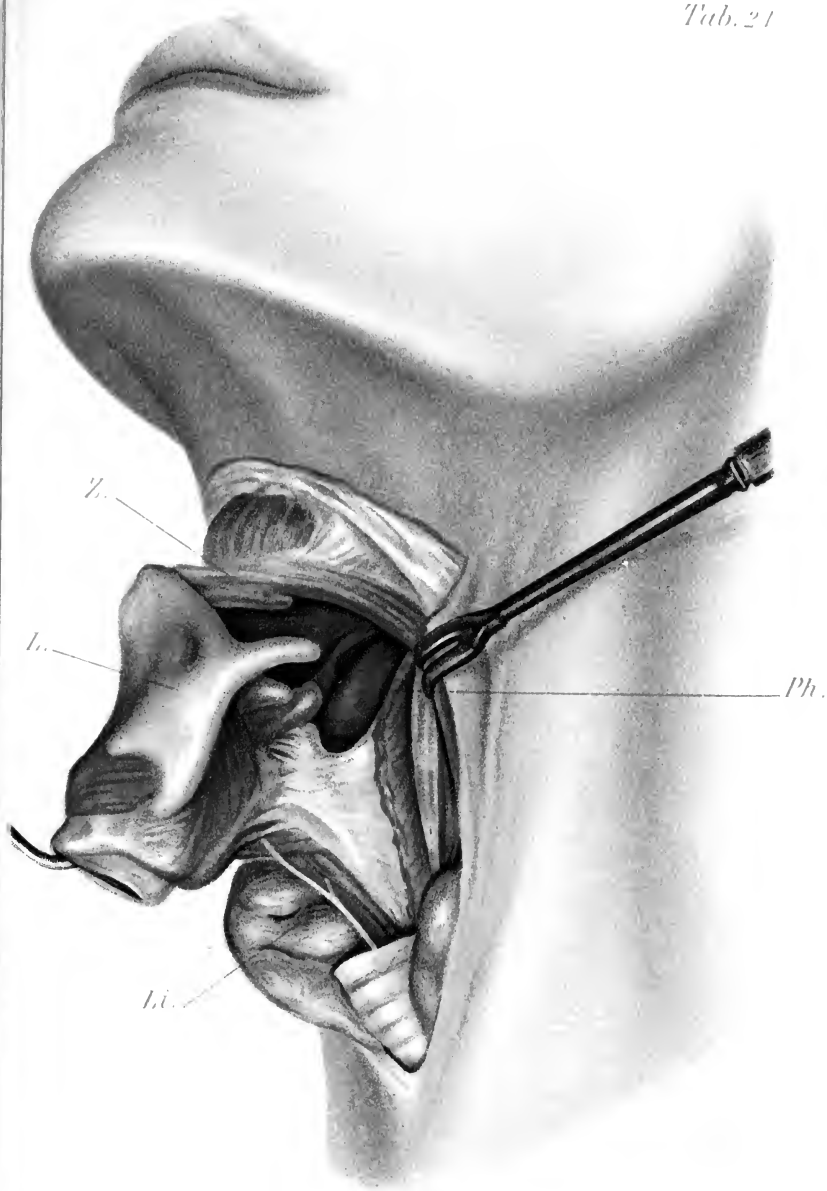
Plate 21.—Extirpation of the Larynx.

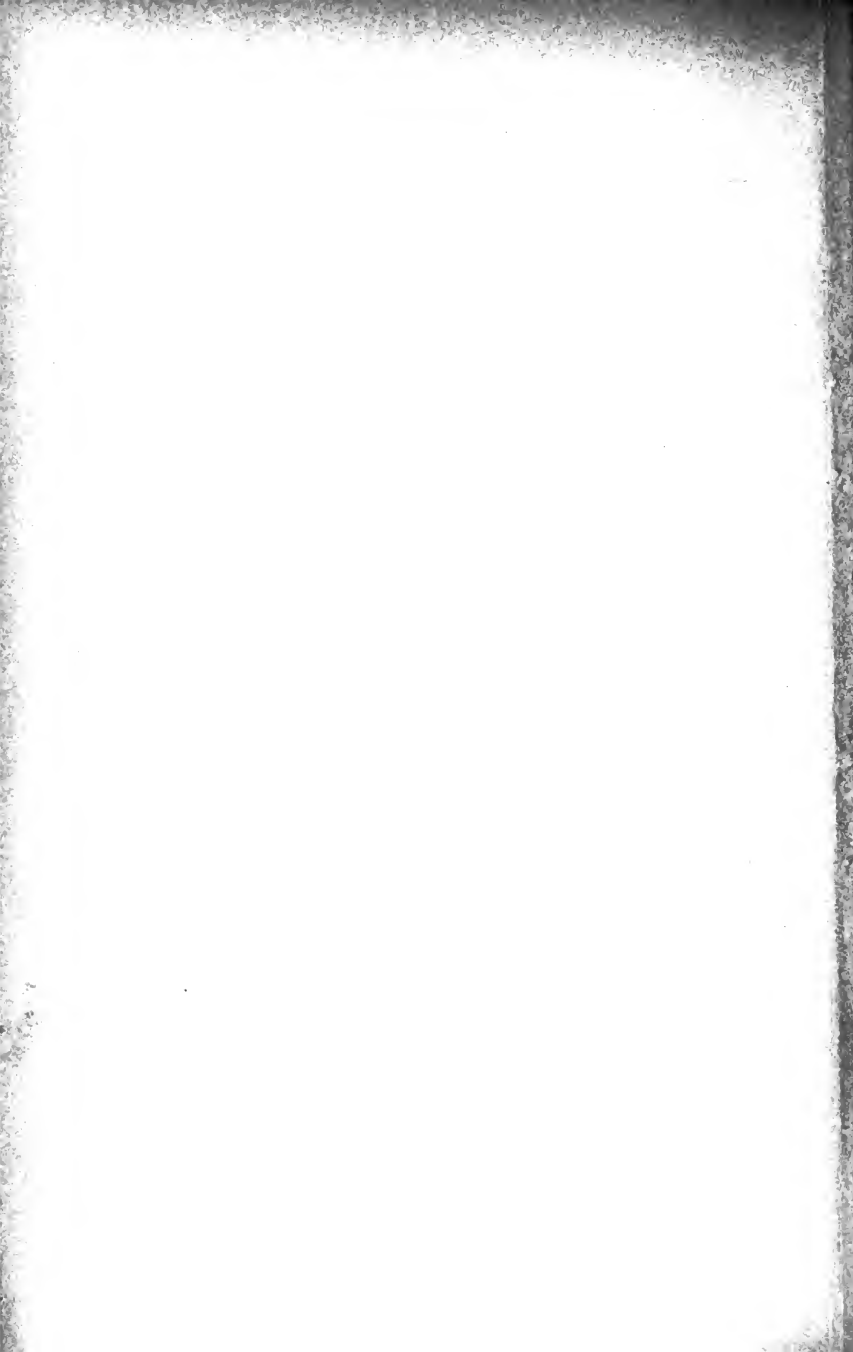
Last step of the operation. The trachea is divided transversely, the larynx (*L*) is elevated, when the connections between the anterior wall of the pharynx and the cricoid cartilage are rendered tense. Above, the larynx is still attached to the hyoid bone (*Z*) by means of the thyrohyoid membrane. *Ph*, posterior wall of the pharynx. *Li*, inferior laryngeal nerve.

level of the hyoid bone. After division of the cervical fascia the attachments of the sternothyroid and thyrohyoid muscles to the thyroid cartilage are severed from the middle line. Gradually, by thus rotating the larynx, its posterior aspect is reached, and the attachments of the constrictors of the pharynx are dissected free from the larynx. After also the upper pole of the thyroid gland has been detached on either side by blunt dissection, the larynx will be rendered sufficiently free to be raised from its place. For this purpose the trachea is divided transversely and drawn upward, and, while the larynx is strongly elevated, the connections between the anterior wall of the pharynx and the cricoid cartilage can be divided with the knife (Plate 21). Finally, the larynx will be attached only to the thyrohyoid membrane, which is divided with scissors on either side after ligation of the superior laryngeal artery. The wound in the pharynx is made as small as possible, and an esophageal tube is introduced. The tampon-cannula is replaced by an ordinary cannula. The wound in the skin is made smaller by means of sutures, and the cavity is tamponed.

Partial extirpation of the larynx always requires laryngofissure as a preliminary operation. This renders possible careful inspection and determination of the parts to be removed. Unilateral resection, according to the rules already laid down, may be practised, or the excision may be confined to the mucous membrane.

Tracheotomy.—Tracheotomy consists in properly opening the trachea through incision. The procedure is in all





cases attended with the introduction of a cannula through the opening into the trachea.

Indications :

(1) *Injuries* of the larynx (punctured, incised, and gunshot-wounds, fractures of the laryngeal cartilages with dislocation of the fragments).

(2) The presence of *foreign bodies* in the trachea which cannot be removed by endolaryngeal procedures.

(3) *Stenosis* of the larynx and the trachea :

(a) Compression-stenosis (goitrous tumors, aneurysms) ;

(b) Occlusion-stenosis. Obstruction of the lumen of the larynx or the trachea, swelling of the laryngeal mucous membrane (diffuse submucous laryngitis ; tuberculous, syphilitic, and typhoid disease of the larynx). Narrowing of the lumen of the larynx, or of the trachea, through exudates (diphtheric croup), through neoplasms (carcinoma, papilloma, granulation-tumors) ;

(c) Cicatricial narrowing of the larynx (after healing of ulcerative processes ; after operative procedures upon the larynx).

(4) As a *preliminary operation*, or in conjunction with other operations upon the larynx and the pharynx, tracheotomy is performed :

(a) To prevent the entrance of blood into the bronchi (tampon-cannula) ;

(b) Following operations, with avoidance of the larynx left open or closed by tampon, in order to supply the patient with air.

(5) *Asphyxia* or *intoxication*, to render possible and to institute artificial respiration.

The trachea is the direct continuation of the larynx, passing in the middle line of the neck toward the upper aperture of the thorax. The upper portion of the trachea lies immediately beneath the superficial structures of the neck. The suprasternal portion is separated from the skin, in addition to the two layers of cervical fascia, by a considerable layer of cellular tissue containing numerous veins. The thyroid gland overlies the trachea between

the third and sixth cartilaginous rings with its lateral lobes connected by the isthmus. Often a pyramidal lobe of the thyroid gland covers also the upper portion of the trachea. The anterior surface of the trachea and of the thyroid gland is covered by the muscles passing from the sternum to the hyoid bone and the thyroid cartilage (sternohyoid, sternothyroid). In the middle line, between the muscles, a strip of trachea is covered only by the cervical fascia. It is through this "white line of the neck" that the trachea is attacked. The isthmus of the thyroid gland divides the trachea into two parts, a supra-thyroid and an infrathyroid. The opening through the former constitutes superior tracheotomy; that through the latter, inferior tracheotomy.

Superior Tracheotomy.—The patient lies in the dorsal decubitus, with the neck over-extended, and a cylindric pillow is placed beneath the shoulders. The operator stands upon the right side of the patient and his assistant upon the opposite side. The cutaneous incision is made accurately in the median line of the neck from the middle of the thyroid cartilage to below the thyroid gland. After the skin and the subcutaneous connective tissue have been incised the tense fascia of the neck is divided upon a grooved director. The inner borders of the sternohyoid muscles come into view, and are retracted symmetrically with blunt hooks. The situation of the trachea is determined by palpation with the finger, and its first cartilaginous ring is exposed by detaching the cellular tissues from the trachea by means of two pairs of anatomic forceps. The field of operation is extended throughout a sufficient extent by incising the layer of fascia stretched between the upper border of the thyroid gland and the trachea, and dislocating the gland downward by means of blunt hooks. Before proceeding with the opening of the trachea the upper rings must be thoroughly exposed by dissection. Then the trachea is grasped just below the cricoid cartilaginous ring accurately in the middle line with a simple sharp tenaculum, raised some-

what and held fixed in this position. The trachea is then incised accurately in the middle line from below upward for a distance of about 1 cm. with a sharp-pointed knife. The opening thus made is distended by means of sharp tenacula and possibly nicked on either side. While the three tenacula are held, undisturbed, in place, the operator introduces the cannula into the trachea. The cutaneous wound is reduced in size by interrupted sutures, and the cannula is firmly fixed in place by means of tapes.

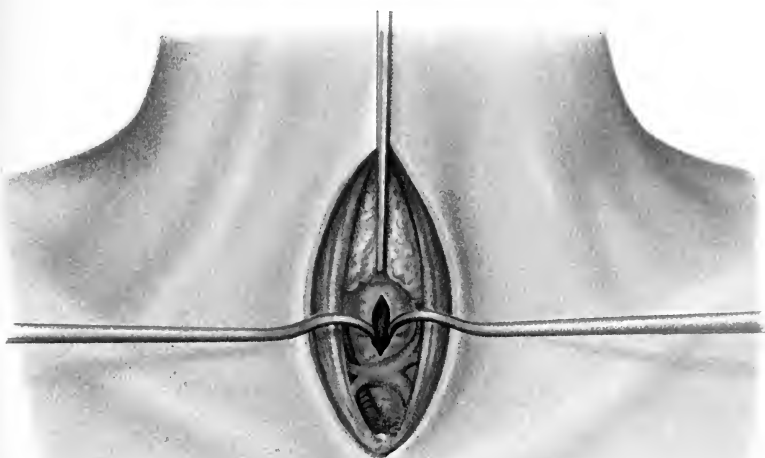
Inferior Tracheotomy.—The patient is placed in the same position as in the performance of superior tracheotomy and a cutaneous incision is made from the lower border of the thyroid gland to below the suprasternal fossa (Fig. 203, c). After the skin and the subcutaneous connective tissue have been penetrated the superficial layer of the cervical fascia is exposed and divided upon a grooved director in the direction of the cutaneous incision. A considerable layer of loose connective tissue is passed through by means of two pairs of anatomic forceps, while the inner border of the sternohyoid muscle on either side is retracted. In the dense layer of connective tissue the middle thyroid veins pass vertically downward to the left innominate vein, and must be avoided or possibly ligated in two places and divided between. During the progress of the blunt dissection the situation of the trachea, toward the convex aspect of which the operation proceeds, should be constantly kept in mind by palpation with the index-finger. Before the trachea is reached the deep layer of the cervical fascia is divided upon a grooved director. Only after this has been done is it possible to isolate the trachea adequately. Before the lumen of the tube is opened the trachea is grasped with a simple sharp tenaculum and raised and fixed at the level of the skin. While the trachea is incised from below upward the index-finger of the left hand is placed in the lower angle of the wound behind the suprasternal notch, so that the left innominate vein, which passes transversely across the trachea behind the manubrium of the sternum, as well as the innominate

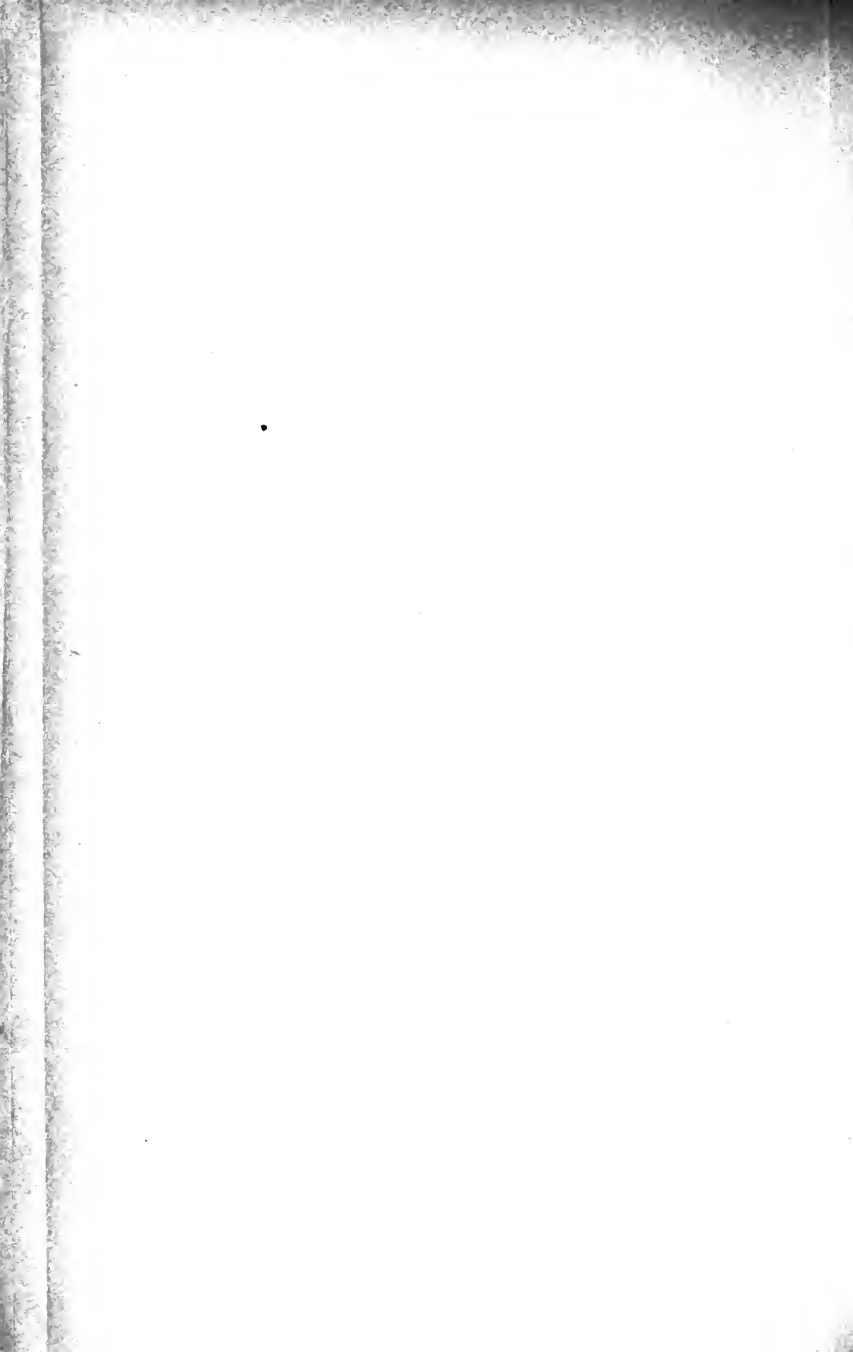
Plate 22.—Inferior Tracheotomy.

The wound is bounded laterally by the sternohyoid muscles. The trachea is exposed and opened upon its anterior aspect for the introduction of the cannula. Venous branches (middle thyroid veins) are seen passing downward from the thyroid gland. Lying close to the right of the trachea in the depth of the wound is the innominate artery.

artery, which is in close relation with the trachea, is sufficiently protected. The tracheal wound is held widely open by means of sharp tenacula, and if necessary is incised to right and left, when the introduction of the cannula is undertaken (Plate 22).

After the cannula has been introduced into the trachea the tenacula are removed. The cannula is fixed by means of tapes and the cutaneous wound is reduced by suture. If the tracheotomy can be performed at leisure and under favorable conditions, the typical mode of procedure is unattended with difficulty. The reverse is the case, however, if the operation must be undertaken in the presence of threatened danger to life or of severe dyspnea. Under these circumstances all of the presence of mind of the operator will be required to maintain the mastery of the situation, which is often a critical one. The smallest veins of the neck are dilated and distended with blood. In the presence of conditions like these the cutaneous incision is enlarged, as by this means the isolation and ligation of the veins are considerably facilitated. The thin walls of the distended veins are not readily recognizable. Veins that interfere with deep dissection are ligated in two places and divided between. At successive stages of the dissection the position of the trachea is constantly kept in mind. Neglect of this precaution may lead to overlooking the trachea. Before the trachea, previously exposed sufficiently, is opened, all bleeding vessels are closed by ligature. A tenaculum is introduced into the trachea for the purpose of placing the organ at rest at the level of the wound, as it would otherwise rise and fall with the respiratory movements, especially in the





presence of dyspnea. The opening into the trachea should be made exactly in the middle line, care being taken that the incision enters the lumen of the tube and does not pass beyond. If the opening is incomplete, it may happen that the tracheal cannula makes a false passage for itself beneath the mucous membrane. A careless incision may, further, injure the posterior wall of the trachea or even the esophagus. After the trachea has been opened the incision is dilated by means of tenacula, while at the same time as the cannula is introduced the trachea is held steadily. The latter precaution is important, as through its neglect the opening may be lost to view in consequence of the movements of the trachea. Apart from the fact that such an event may render impossible the proper introduction of the cannula, subcutaneous emphysema may result and extend from the wound to the cellular tissue of the neck.

The cannula (Fig. 204) in accordance with its curvature is introduced in an arched manner. The whistling sound



FIG. 204.—Tracheal cannula.

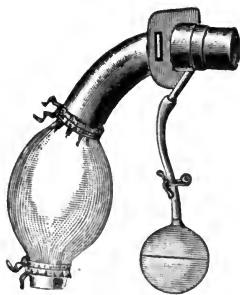


FIG. 205.—Trendelenburg's tampon-cannula.

with which the air, after a short period of apnea, escapes from the tube is the indication that the cannula is properly

placed. The cannula of Krieshaber (Fig. 206) is much used, particularly in France; it is armed with a conical pilot, for introduction. When the cannula is in place, the pilot is replaced by a permanent internal cannula (Fig. 206, *b*). Until the cannula is secured by means of the tapes the tube must be held immovably in the wound.

Tracheotomy for the purpose of tamponade of the trachea, with simultaneous insurance of access of air, is sometimes practised as a preliminary procedure in bloody operations about the mouth, the larynx, and the pharynx.

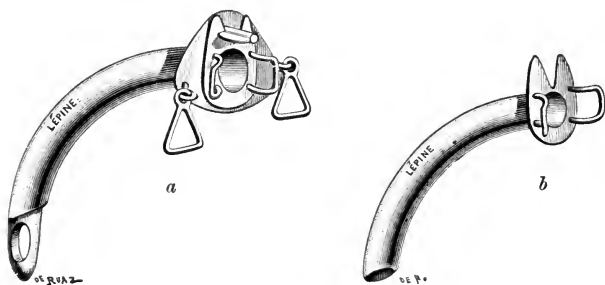


FIG. 206.—Krieshaber's cannula: *a*, cannula armed with pilot for introduction; *b*, permanent internal cannula.

The tampon-cannula is intended to prevent the entrance of blood in the course of operations, and the aspiration of secretion from wounds in the further progress of the case. The so-called tampon-cannula employed for this purpose is surrounded with compressed sponge (Hahn), which swells in the trachea and completely occupies its lumen; or the tube is surrounded by a small rubber bag (Trendelenburg) which can be filled with air by means of bellows (Fig. 205). The bag is distended with air after the cannula has been introduced, and adapts itself accurately to the interior of the trachea, occluding its lumen as a stopper does the neck of a flask.

Intubation.¹—Intubation is a bloodless procedure intended to render the larynx patulous in the presence of respiratory obstruction by the introduction of a rigid tube. The operation was recommended a number of years ago as a substitute for tracheotomy in cases of laryngeal stenosis from croup, and it has in the course of time secured more and more supporters.

The most important *indication* for intubation consists in laryngeal stenosis such as is observed in conjunction with laryngeal croup. Further indications are afforded by the various forms of chronic stenosis of the larynx observed in adults. Under these conditions intubation is a substitute for tracheotomy. Intubation has been recommended also as a palliative measure in cases of whooping-cough and of laryngeal spasm. The procedure is contraindicated :

- (a) In the presence of complete occlusion of the nasopharyngeal space ;
- (b) In the presence of intense edema of the glottis ;
- (c) In cases of diphtheria complicated by retropharyngeal abscess.

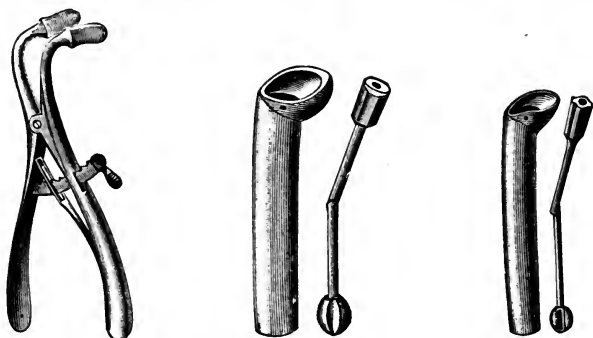
The original outfit of O'Dwyer is still the best, in spite of numerous modifications. This consists of :

- (1) A mouth-gag (Fig. 207).
- (2) A series of metallic tubes of varying size (Figs. 208 and 209). Each tube presents at its upper extremity a shoulder resembling the rim of a hat, by means of which it rests upon the vocal bands. Upon the left side of this shoulder is a small opening for the attachment of a thread. Each tube is further provided with a conductor intended to facilitate the guidance of the rigid tube.
- (3) An intubator (Fig. 210), to which the conductor spoken of is attached by means of a screw. Tube and conductor should fit accurately. By means of a lever the tube can be detached from the conductor at the proper moment.

- (4) An extubator (Fig. 211). The extremity of this instrument, which is constructed similarly to the intuba-

¹ For this section I am indebted to Dr. Demetrio Gallatti, of Vienna.

tor, can be introduced into the lumen of the tube, and be impacted there, and thus serve for the removal of the tube.



O'DWYER'S OUTFIT FOR INTUBATION.

FIG. 207.—Mouth-gag. FIG. 208 and FIG. 209.—Tubes with conductors.

The operation is performed as follows :

A nurse takes the child to be intubated upon her lap, grasps its lower extremities between her knees, and with



FIG. 210.—Intubator.

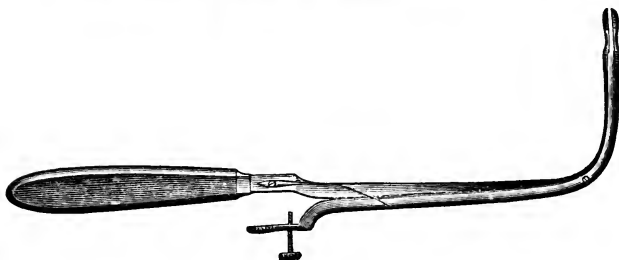


FIG. 211.—Extubator.

her right hand holds its head, and with her left, its hands. An assistant holds the mouth open by means of the gag,

while the operator lifts the epiglottis with the index-finger of his left hand and draws it forward so that the entrance to the larynx is clear. The intubator, adapted to the corresponding tube, is now introduced alongside the finger. The tube is held horizontally, accurately in the median plane, with the handle of the instrument vertical. If the handle of the intubator is elevated, the lower extremity of the tube slips by the finger into the entrance of the larynx. If, after a slight movement upward, it is certain that the tube has entered the larynx, the former is then pushed gently onward, detached from the intubator, either with the finger of the left hand or by means of slight pressure forward upon a sliding arrangement connected with the handle of the instrument, and with the index-finger of the left hand forced deeply into the larynx. If the child breathes freely, the thread attached to the tube may be permitted to remain, being brought out of the mouth and attached to the cheek by means of adhesive plaster, or the index-finger is again introduced into the mouth, the tube held in place, and the divided thread slowly removed.

Extubation is effected in much the same manner. Under the guidance of the index-finger of the left hand the extubator is introduced into the mouth and its closed blades are passed into the lumen of the tube. By pressure upon the upper portion of the instrument its two blades are separated and the tube can thus be carefully removed.

In most cases of intubation the use of the mouth-gag can be dispensed with. Under such circumstances the index-finger of the left hand must be protected by a metallic band.

Pharyngotomy.—The pharynx can be opened :

(1) In its upper part by temporary lateral resection of the lower jaw ; (2) in its laryngeal portion by transverse division of the thyrohyoid membrane (Malgaigne) ; (3) in an extensive manner by lateral incision (Langenbeck), in consequence of which the deeper portions of the larynx are made accessible.

Plate 23.—Infrahyoid Pharyngotomy.

Preliminary tracheotomy has been performed and a cannula introduced. In the pharyngotomy wound can be seen the stumps of the divided hyoid muscles, as well as the hyoid bone (*H*).

The epiglottis (*E*) is drawn out of the wound and the aryepiglottic folds (*Ae*) are made tense. The floor of the wound is constituted by the posterior wall of the pharynx.

Infrahyoid Pharyngotomy.—Division of the thyrohyoid membrane renders the laryngeal portion of the pharynx accessible. This mode of opening the pharynx and exposing the larynx (Malgaigne's infrahyoid laryngotomy) is suitable for the performance of surgical operations upon the epiglottis, in the larynx, and upon the pharynx.

Infrahyoid pharyngotomy is performed :

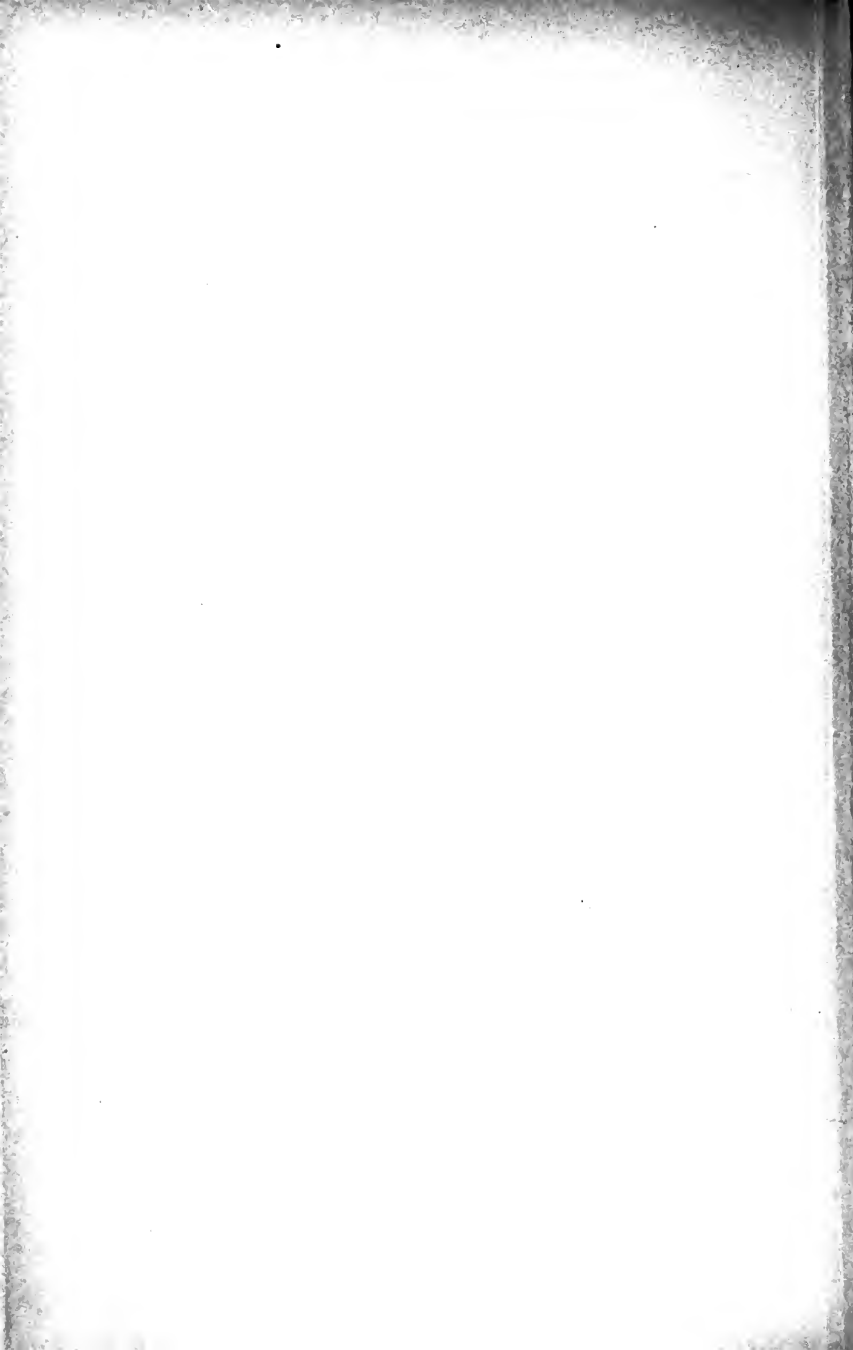
For the removal of *foreign bodies* from the larynx and the pharynx ;

For the extirpation of tumors of the epiglottis, the larynx, and the pharynx ;

For the treatment of cicatricial strictures of the esophagus.

Steps of the Operation.—The patient is placed in the dorsal decubitus with the cervical portion of the spinal column overextended, and preliminary tracheotomy is performed. By means of palpation with the finger the position of the hyoid bone and of the thyroid cartilage is determined. The cutaneous incision is made transversely over the thyrohyoid membrane parallel with and close to the body of the hyoid bone (Fig. 203, *a*). After the cervical fascia has been opened and the sternohyoid and thyrohyoid muscles have been divided transversely, the membrane is exposed to view. It is detached from the posterior surface of the hyoid bone, and the pharynx is opened in the middle line at the upper border of this bone. By this method only is the epiglottis protected, falling downward after division of the hyo-epiglottic ligament, when also the lateral portions of the thyrohyoid ligament may be divided with a single stroke of the scissors. The epiglot-





tis, the aryepiglottic folds, the vocal bands, the interior of the larynx, as well as the walls of the laryngeal portion of the pharynx, are exposed for possible surgical intervention (Plate 23).

Lateral Pharyngotomy.—Lateral incision of the pharynx has been recommended by Langenbeck for the removal of extensive tumors in the deeper retrolaryngeal portions of the pharynx. By dislocation of the larynx, all parts of the wall of the pharynx can be brought into the field of operation. Preliminary tracheotomy is performed. The cutaneous incision passes on the affected side from the middle of the body of the lower jaw over the greater cornu of the hyoid bone down to the cricoid cartilage or beyond this close to the tracheotomy wound. The superficial fascia of the neck and the platysma are passed, and the omohyoid is divided. Dissecting deeply, the lingual and superior thyroid arteries and branches of the facial vein are ligated and divided. The posterior belly of the digastric and the stylohyoid muscle are detached from the hyoid bone and divided, when the lateral wall of the pharynx is sufficiently exposed for incision. In the gaping wound in the pharynx, the larynx, the epiglottis, and the base of the tongue are visible. By rotation of the larynx, any desired part of this organ can be brought into the field of operation (Plate 24).

External Esophagotomy.—Opening of the esophagus in the neck is indicated :

(1) In the presence of *foreign bodies* in the esophagus ;
(2) In the presence of impermeable high *stenoses* of the esophagus, from carcinoma or cicatricial stricture, for the formation of a nutritive fistula beyond the narrowed situation ;

(3) In the presence of *cicatricial strictures* more deeply seated :

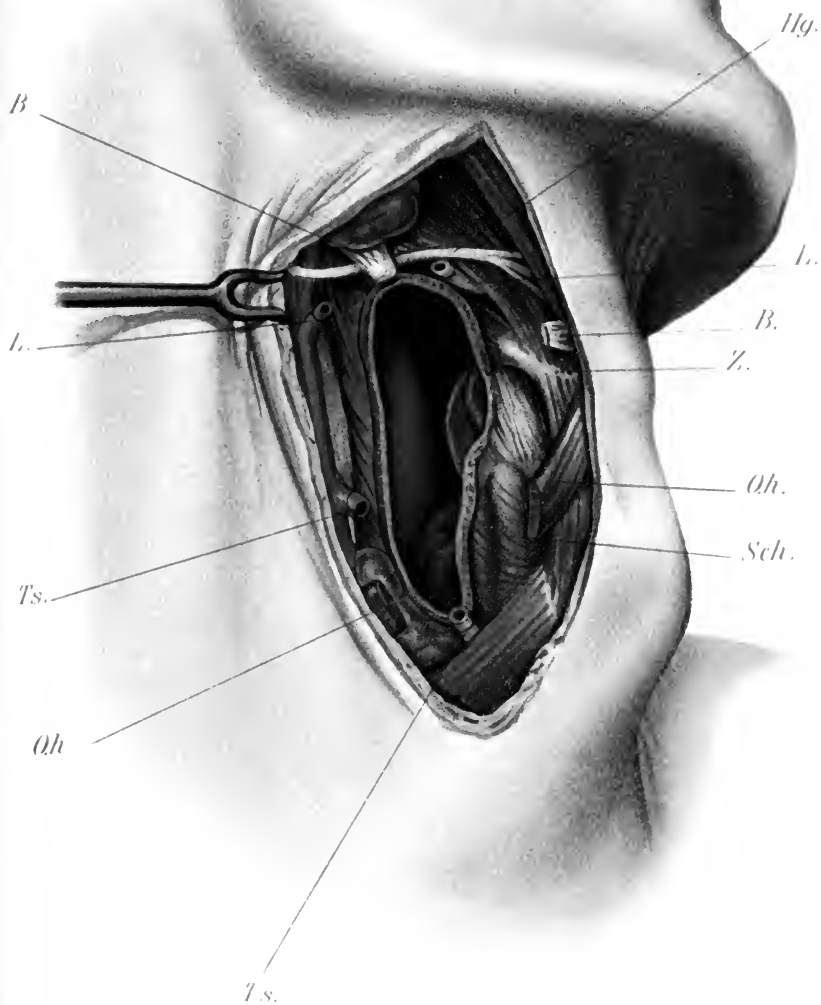
(a) For the performance of dilatation through a fistula established ;

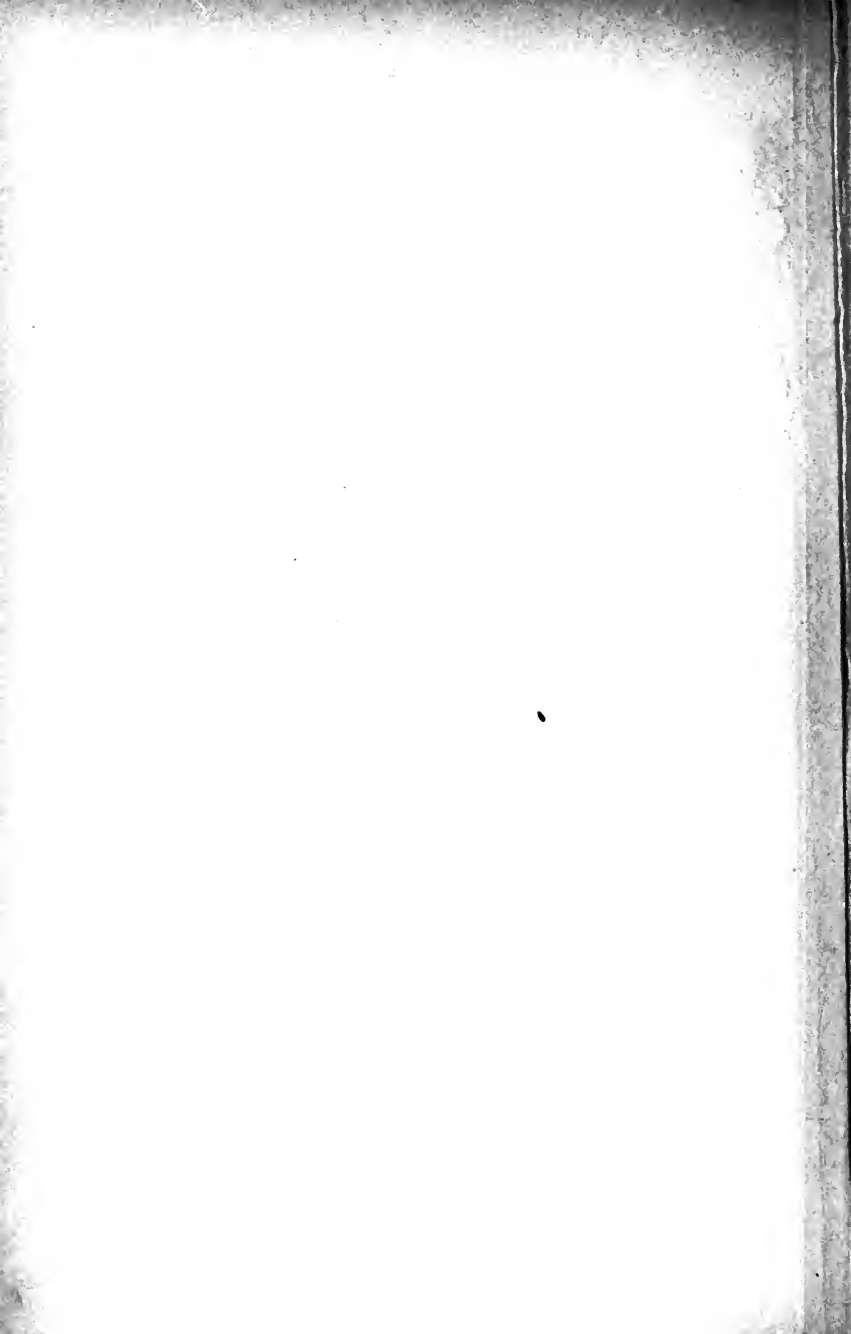
(b) For the performance of internal esophagotomy from the wound (Gussenbauer's combined esophagotomy).

Plate 24.—Lateral Pharyngotomy by the Method of Langenbeck.

The capacious wound is bounded externally by the carotid artery, on which the stumps of the divided lingual artery (*L*) and the superior thyroid artery (*Ts*) are visible. Internally, the upper and lower hyoid muscles, the mylohyoid, hyoglossus, sternothyroid, thyrohyoid, and the stump of the omohyoid (*Oh*) can be seen. At the upper angle of the wound is the submaxillary gland, the stumps of the digastric muscle (*B*), and the hypoglossal nerve (*Hg*). The pharynx is widely opened laterally. In the gaping wound can be seen the epiglottis, the larynx, and the posterior wall of the pharynx. *Sch*, inferior constrictor of the pharynx. *Z*, hyoid bone.

The esophagus is opened just below the pharynx, beyond the cricoid cartilage, where it lies behind the trachea and projects upon its left side. The inferior laryngeal nerve, which passes from below upward between the trachea and the esophagus, must be protected. The patient is placed in the dorsal decubitus, with the cervical spine overextended and the head directed toward the right. The cutaneous incision is made along the anterior border of the sternomastoid muscle as in the operation for ligation of the common carotid artery. The sheath of this muscle is opened and the muscle itself retracted outward. The deep layer of the cervical fascia is divided upon a grooved director and the whole mass of vessels and nerves is likewise displaced outward with blunt hooks. If the thyroid gland is at the same time dislocated inward, the trachea comes into view and, behind it, projecting somewhat beyond its left border, the esophagus, which is to be recognized by its different color and the longitudinal arrangement of its fibers. The gullet is grasped with fixation-threads, drawn to the level of the wound and opened with scissors in the line of the cutaneous incision (Fig. 212). If the operation has been so performed that the wound in the esophagus can be closed for primary union—for instance, after extraction of foreign bodies—the wall of the esophagus is approximated with interrupted sutures in two tiers. The first row of sutures approxi-





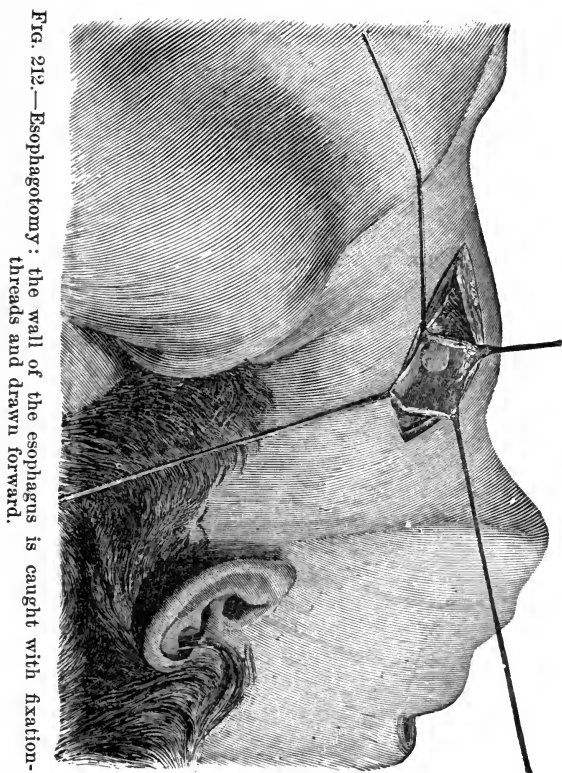


Fig. 212.—Esophagotomy: the wall of the esophagus is caught with fixation-threads and drawn forward.

mates the mucous membrane and the second the muscular layer. If the operation has been performed for the purpose of establishing an esophageal fistula—for instance, for dilatation of a stricture of the esophagus—the wall of the esophagus is united to the skin by means of interrupted sutures.

Ligation of Vessels in the Cervical Region.—

Innominate Artery.—The innominate artery, the common trunk of the carotid and the right subclavian artery, arises from the arch of the aorta. Lying against the trachea, the large vessel passes to the right and upward, dividing into the two vessels named at the level of the sterno-clavicular articulation. Covered by the manubrium of the sternum, the innominate artery is accessible from the suprasternal fossa behind the free border of the sternohyoid or of the sternothyroid muscle. The trunk of the vessel is crossed by the left innominate vein as it passes transversely. The recurrent laryngeal nerve winds around the innominate artery. In ligating the vessel the patient occupies the dorsal decubitus, with the neck extended. According to Graefe, the cutaneous incision is made along the anterior border of the sternomastoid muscle in such a way that its lower extremity extends beyond the sternal attachment of the muscle. The sheath of the muscle is opened and the median fascia of the neck divided, when the inner border of the sternohyoid becomes visible and below this the edge of the sternothyroid. These muscles are retracted with blunt hooks. Along the right side of the trachea progress is made downward, the common carotid artery being first reached and further on the innominate, lying by the side of the trachea. The artery can be isolated from the surrounding loose cellular tissues by blunt dissection and it is then ligated.

The same plan of procedure is followed in looking for the vessel through an incision made vertically in the middle line of the neck over the suprasternal notch, instead of the incision of Graefe.

Carotid Artery.—The carotid artery on the right side is

a branch of the innominate, while upon the left side it arises from the arch of the aorta. The common carotid artery on each side passes along the side of the trachea and the larynx almost vertically upward upon the neck to the level of the thyroid cartilage, where it divides into its primary branches, the internal and the external carotid. In its course the carotid artery holds such relations with the jugular vein, the vagus nerve, and the descending branch of the hypoglossal nerve in the loose cellular tissue that the vein lies to the outer side of the artery. The vessels are covered by fibrous fascia that also constitutes the posterior wall of the sheath of the sternomastoid muscle. To render the artery accessible it will thus be necessary to expose and retract the fibers of the sternomastoid muscle and to divide carefully the posterior wall of its sheath.

Ligation of the Common Carotid Artery.—The patient occupies the dorsal decubitus, with the neck stretched and the head rotated toward the healthy side. By palpation the situation of the larynx and the course of the sternomastoid muscle are determined. The artery is best exposed at the level of the cricoid cartilage just above the point where it is crossed by the omohyoid muscle. The cutaneous incision is made along the anterior border of the sternomastoid from the thyroid cartilage for a distance downward of 8 or 10 cm. (Fig. 213, *b*). After the skin and the platysma muscle are divided the sternomastoid muscle, covered by the fascia, comes into view. The fascia is divided in the direction of the cutaneous incision and the inner border of the exposed muscle is carefully retracted outward, when the so-called middle fascia of the neck and the omohyoid muscle come into view. Above this muscle the fascia is divided carefully upon the grooved director and the artery isolated by blunt dissection and raised out of its bed. To the outer side of the artery lies the internal jugular vein, and between the two vessels the vagus nerve.

Ligation of the External Carotid Artery.—The patient is placed in the same position as in ligation of the com-

Plate 25.

(1) Exposure of the carotid artery in the neck. The sternomastoid muscle (*K*) is retracted outward; the deep layer of the cervical fascia (*F.c.*) is divided, and the common carotid artery (*C*), the jugular vein (*J*), the vagus nerve, and the descending branch of the hypoglossal nerve are thus brought into view. The bifurcation of the common carotid into the internal and external carotid is also discernible. The origin of the thyroid from the external carotid, which in the illustration is situated abnormally far outward, has been freed by dissection. *Z*, inferior hyoid muscles.

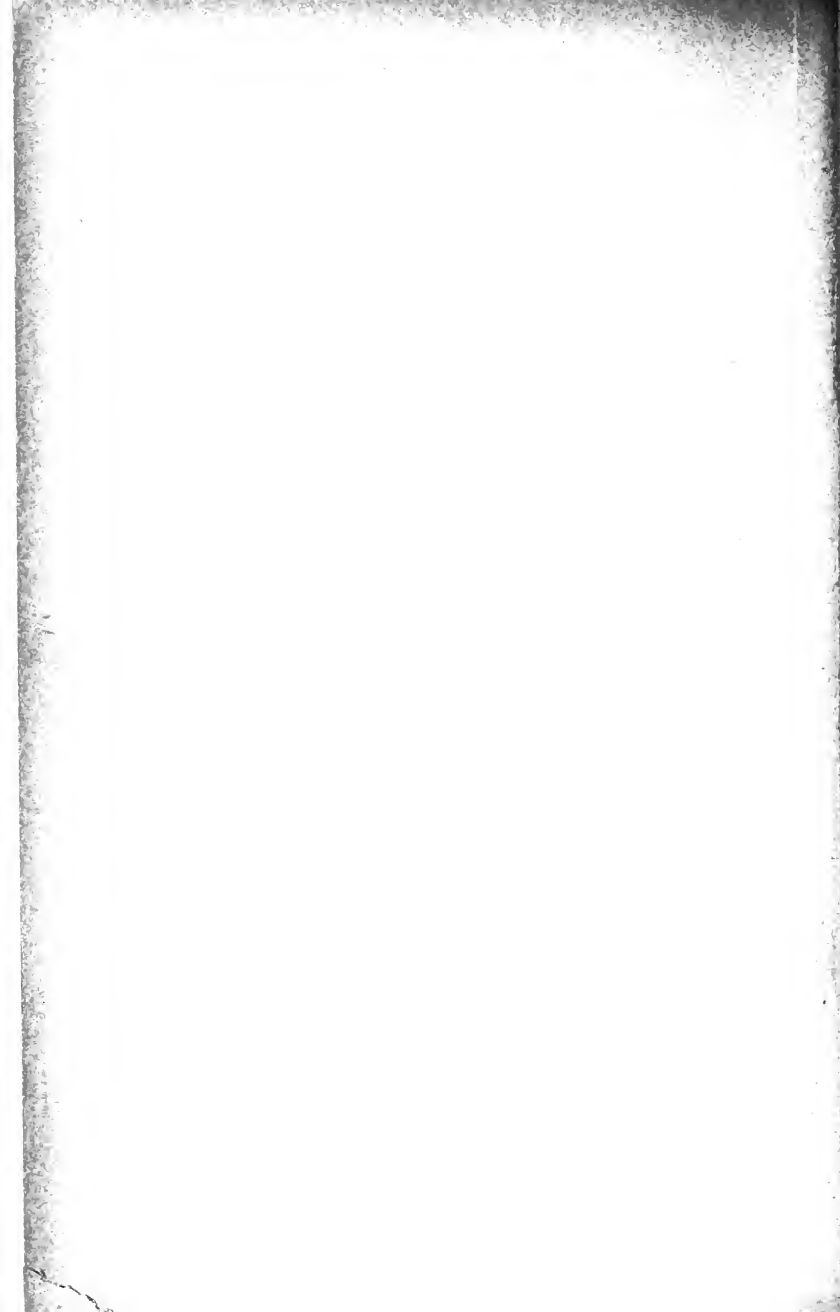
(2) Exposure of the subclavian artery below the clavicle. The pectoralis major muscle (*P*, to the left) is divided in the direction of the cutaneous incision to the deltoid muscle (*D*). Below the former the subclavian artery (*A*) is visible between the vein (*V*) and the brachial plexus of nerves (*P*, to the right).

mon carotid artery, and the incision through the skin is made along the anterior border of the sternomastoid muscle, with its upper extremity at the level of the hyoid bone. After the skin, the platysma muscle, and the superficial fascia have been divided the common facial vein comes into view and is retracted toward the middle line by means of blunt hooks. The trunk and the branches of the external carotid artery are exposed by blunt dissection in front of the greater cornu of the hyoid bone between the omohyoid muscle and the posterior belly of the digastric muscle.

An incision like that described suffices also for the exposure of the large branches of the external carotid artery, the external maxillary (facial), the lingual, and the superior thyroid, at their points of origin, for purposes of ligation. Of the branches of the external carotid, the facial, the superior thyroid, and the lingual artery are of surgical importance.

The *superior thyroid artery* arises from the trunk of the external carotid, just above the bifurcation, at the level of the hyoid bone, and it passes in an arched direction downward to the thyroid gland. To ligate the vessel a cutaneous incision is made along the anterior border of the





sternomastoid muscle from the hyoid bone to the thyroid cartilage. After division of the skin, the platysma muscle, and the cervical fascia the vessel, passing downward in an arched direction, is found at the greater cornu of the hyoid bone.

The *lingual artery* arises from the external carotid at about the level of the hyoid bone, and it passes in a slightly curved direction forward and upward, entering the substance of the tongue under cover of the hyoglossus muscle.

Ligation of the Lingual Artery.—An arched incision is made from the angle of the jaw to the hyoid bone,

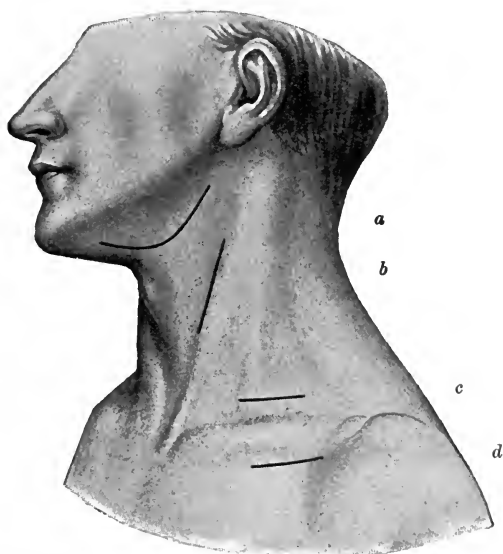


FIG. 213.—Ligation of the vessels of the neck: cutaneous incisions; *a*, lingual artery; *b*, common carotid artery; *c*, subclavian artery above the clavicle; *d*, subclavian artery below the clavicle.

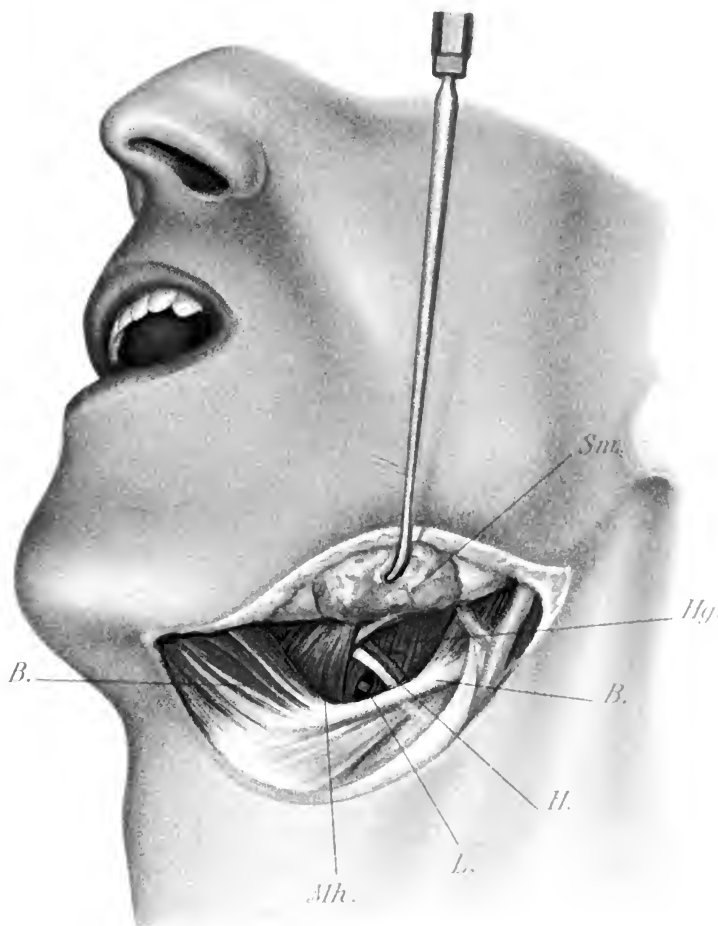
thence ascending almost to the chin (Fig. 213, *a*). After division of the skin and the platysma muscle the super-

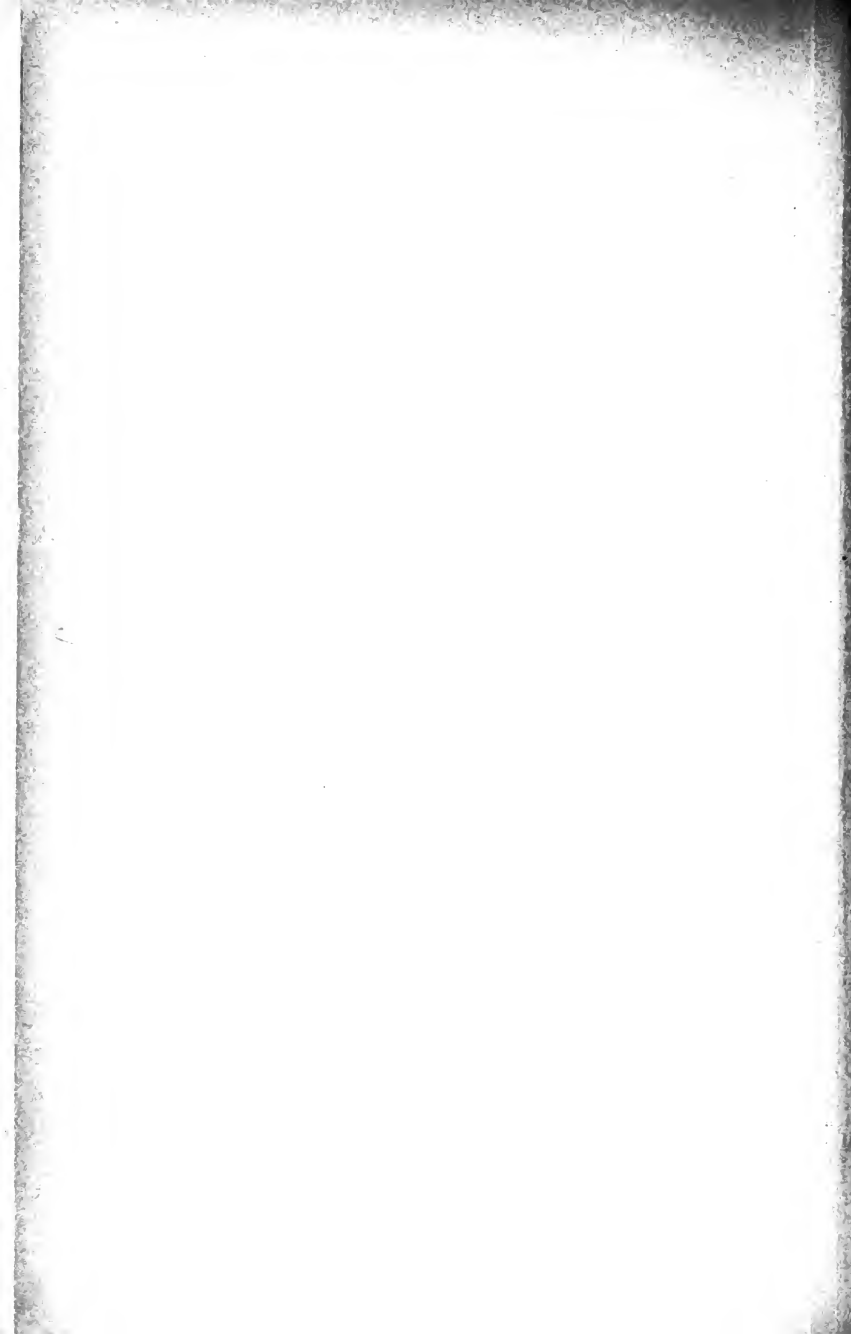
Plate 26.—Exposure of the Lingual Artery.

The submaxillary gland (*Sm*) is raised from its bed after division of the skin and the fascia; the lingual trigone is thus rendered visible. It is bounded by the tendon of the digastric muscle (*B*), the outer border of the mylohyoid muscle (*Mh*), and the hypoglossal nerve (*H*), which is accompanied by a vein. The floor of the triangle is formed by the hyoglossus muscle (*Hg*), the fibers of which are separated within the triangle, and the artery (*L*) is thus rendered visible.

ficial layer of the cervical fascia comes into view and beneath this the submaxillary gland is visible. The fascia is slit open at a point corresponding to the lower margin of the gland, which is raised from its bed by blunt dissection and retracted upward. Covered by the deep layer of the cervical fascia may be seen the shining tendon of the digastric muscle curving in an arched manner, and, above, the hypoglossal nerve, accompanied by a vein, passes horizontally. The free border of the mylohyoid muscle forms with the tendon of the digastric muscle and the hypoglossal nerve a triangle whose floor is constituted by the fibers of the hyoglossus muscle. To expose the lingual artery the fascia covering this lingual trigone is first divided. Then the fibers of the hyoglossus muscle ascending vertically from the hyoid bone to the tongue and forming the floor of the triangle referred to must be separated by blunt dissection, when, if the layer of muscle has been passed, the artery becomes visible on the floor of the triangle, and can be ligated (Plate 26). Ligation of the lingual artery can also be undertaken more proximally below the posterior belly of the digastric muscle, close to the origin of the vessel. This method has no advantage over the previously described operation of Pirogoff for the purpose of making the tongue bloodless in advance of operations.

Ligation of the Subclavian Artery.—The subclavian artery on the right side is a branch of the innominate, on the left side arising directly from the arch of the aorta, lies at its origin at the apex of the pleural cavity. It





leaves the pleural cavity through the upper aperture of the thorax, and reaches the anterior surface at the first rib, in the interval between the scalenus anticus and medius muscles (posterior scalene interval, Fig. 214). From this situation it descends toward the arm. The point at which the artery crosses the first rib is marked by a slight elevation, the tubercle of Lisfranc or the

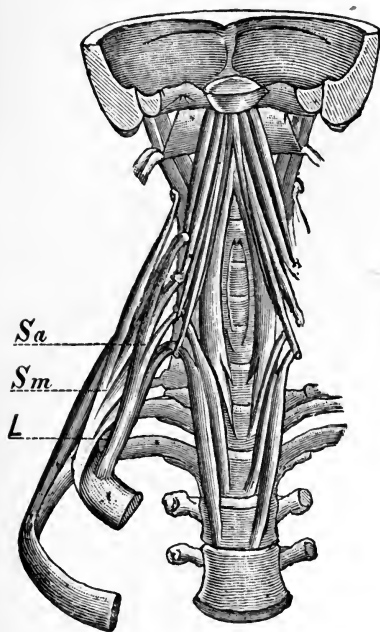


FIG. 214.—Posterior scalene interval (*L*), between the scalenus anticus (*Sa*) and the scalenus medius (*Sm*) muscle.

scalene tubercle. The cords of the brachial plexus also reach the arm through the posterior scalene interval. The nerves lie above and to the outer side of the artery (Plate 27).

The subclavian vein passes in the interval between the sternomastoid and the scalenus anticus (anterior scalene interval), to unite with the internal jugular vein. The

Plate 27.—Situation of the Subclavian Artery in the Supraclavicular Fossa.

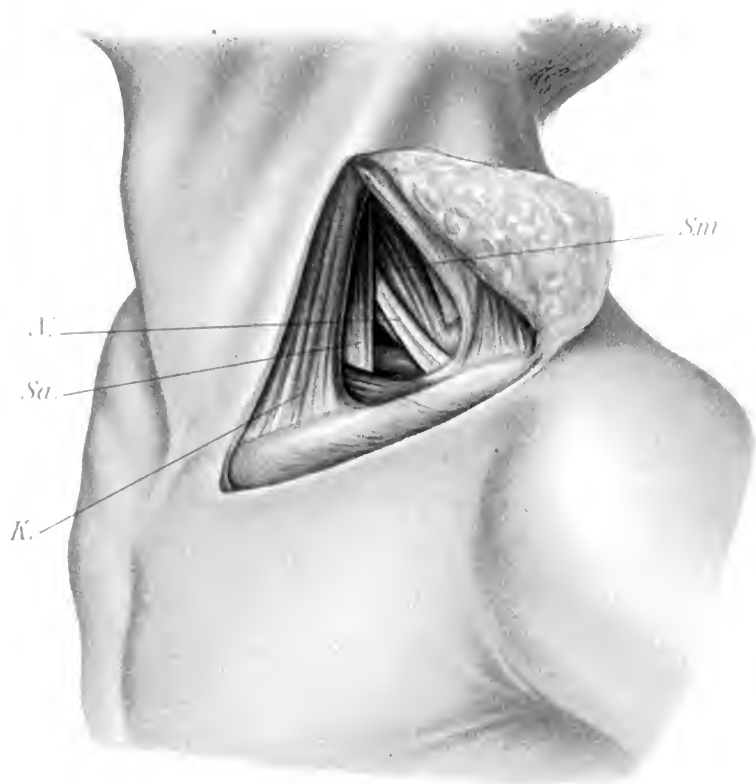
The anterior scalene interval is visible between the sternomastoid (*K*) and the scalenus anticus (*Sa*); also the posterior scalene interval between the scalenus anticus and the scalenus medius (*Sm*). Through the latter space pass the nerves of the brachial plexus (*N*), and to the inner side of the nerves, lying upon the first rib, the artery.

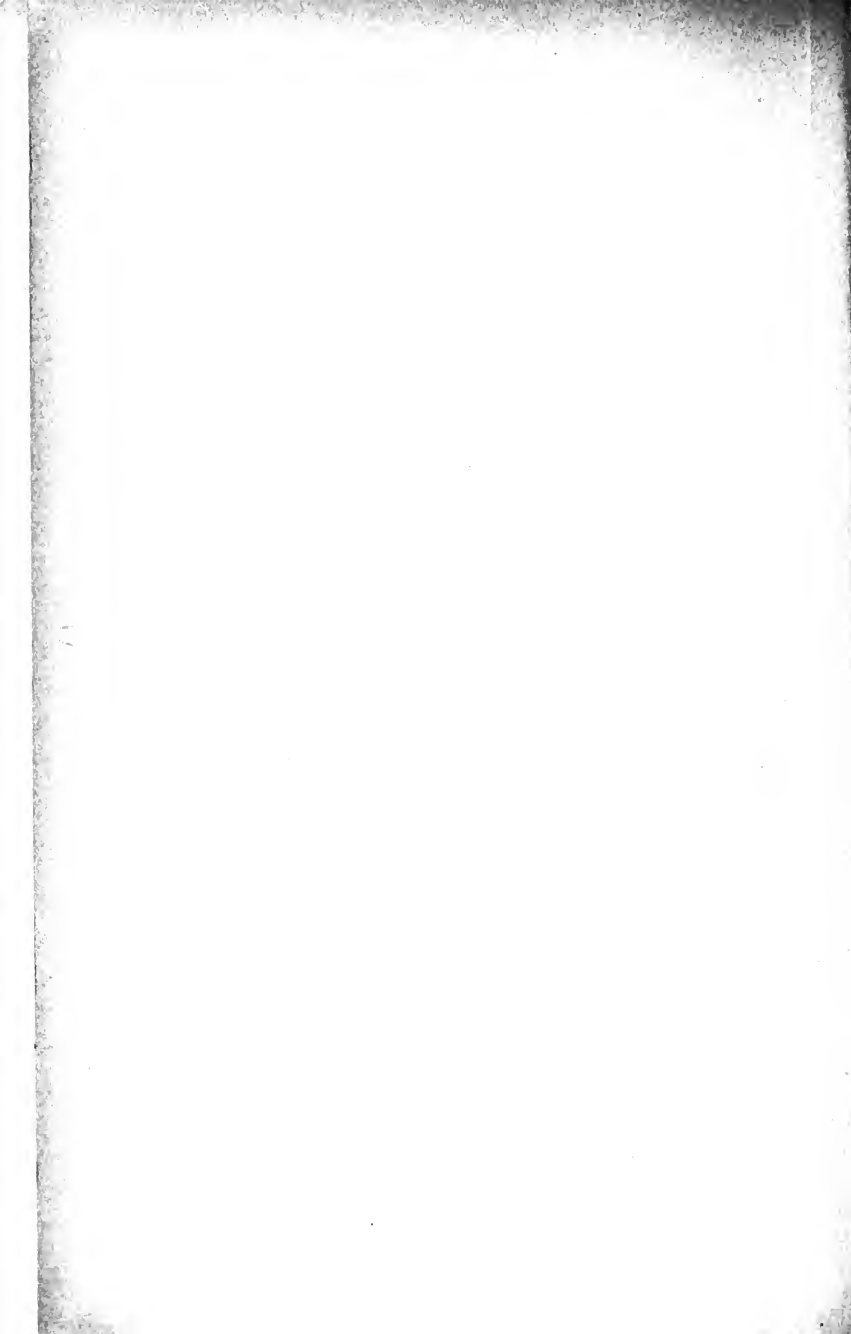
subclavian vein is thus separated from the subclavian artery by the scalenus anticus muscle.

The subclavian artery is exposed for ligation above the clavicle, in the supraclavicular fossa, just at the point where it lies upon the first rib after emerging from the scalene interval; below the clavicle, at a point corresponding with the lower margin of the first rib.

Ligation of the Subclavian Artery Above the Clavicle.—The patient lies with the upper portion of the trunk elevated and the head rotated toward the opposite side. The arm lies against the trunk. Gentle traction on the arm brings into view the boundaries of the supraclavicular fossa. By this means the clavicle can be seen, forming the base of the triangular space, whose anterior boundary is formed by the outer border of the sternomastoid muscle and the posterior boundary by the anterior border of the trapezius. The plane of the supraclavicular fossa is more or less depressed.

A transverse cutaneous incision is made parallel with and a finger's breadth above the clavicle, from the outer border of the sternomastoid muscle to the anterior border of the trapezius (Fig. 213, *c*), dividing the skin, the platysma muscle, and the supraclavicular nerves. By blunt dissection a passage is made through the loose connective tissue of the supraclavicular fossa to the deep layer of fascia that covers the scalenus muscles, the brachial plexus, and the subclavian artery. After the fascia has been divided, the position of the posterior scalene interval is made out, and the situation of the artery is determined by palpation with the finger just behind the attachment





of the scalenus anticus to the first rib, to the outer side of the scalene tubercle. The artery lies upon the first rib at the deepest point of the interval, to the inner side of the nerves of the brachial plexus, and can be isolated for ligation between two pairs of anatomic forceps.

Ligation of the Subclavian Artery Below the Clavicle.—The patient occupies the same position as in the operation just described. The line of separation of the clavicular portions of the deltoid and pectoralis major muscles is indicated below the clavicle by a triangular depression (Mohrenheim's triangle). By palpation with the finger the situation of the coracoid process of the scapula is carefully determined, and a cutaneous incision is made a finger's breadth below the clavicle to above the apex of the coracoid process (213, *d*). The clavicular portion of the pectoralis major muscle is divided in the line of the cutaneous incision and after division of the loose coracoclavicular fascia the upper border of the pectoralis minor is exposed and is retracted downward with blunt hooks. In the loose connective tissue below the clavicle there appear in the direction toward the anterior scalene interval above, the readily accessible subclavian vein, and to its outer side the great mass constituted by the brachial plexus. The artery lies between the vein and the nerves, closer to the wall of the thorax, and can be separated from the loose cellular tissue by blunt dissection (Plate 25). Following another method, entrance is gained to Mohrenheim's triangle, after making the same cutaneous incision, and the artery is exposed without division of the pectoralis major. The superficial fascia is divided and after separation of the margins of the pectoralis major and deltoid muscles the fossa of Mohrenheim is rendered accessible. In the depth of this fossa the mass of vessels and nerves is visible below the clavicle after division of the coracoclavicular fascia.

Of the branches of the subclavian artery the following are of surgical importance: the inferior thyroid artery, which is ligated to bring about atrophy of tumors of the thyroid gland; the vertebral artery, whose ligation has

been recommended in the treatment of epilepsy ; the internal mammary artery, whose ligation may become necessary in connection with contused or punctured wounds of the anterior wall of the thorax.

Ligation of the Inferior Thyroid Artery.—The artery is exposed for ligation at the point where it lies upon the vertebral column (or rather the longus colli muscle) and passes behind the common carotid artery in a curved direction upward and inward to the thyroid gland. Kocher has recommended an oblique incision extending upward and outward from above the suprasternal notch along the anterior margin of the sternomastoid. The common carotid artery is exposed and drawn outward. At the inner side of the vessel progress is made between the artery and the thyroid gland drawn toward the middle line down to the spinal column, where the artery will be found pursuing its characteristic arched course, with the convexity upward. In ligating the vessel care must be taken not to include the inferior laryngeal nerve, the motor nerve of the larynx, which lies in close relation with the vessel.

According to the method of Wölfler, the vessel is exposed by an incision at the external margin of the sternomastoid to the inner aspect of the scalenus anticus muscle, before it crosses the carotid artery.

The vertebral artery arises from the subclavian artery at the height of its convexity, to the median aspect of the thyrocervical trunk. Ascending at the inner border of the scalenus anticus muscle, between this and the longus colli muscle, it reaches the transverse process of the sixth cervical vertebra, where it enters the canal formed by the six upper cervical vertebrae. The cutaneous incision is made at the outer border of the sternomastoid muscle from the clavicle to the larynx. If the sternomastoid, together with the large vessels, is retracted inward, access can be gained upward to the transverse process of the sixth cervical vertebra (recognizable from the prominent carotid tubercle) along the border of the scalenus anticus muscle ; beneath this process the artery will be found be-

tween the margins of the scalenus anticus and the longus colli muscles.

Operation for Goiter.—As a result of the symptoms developed after total extirpation of the thyroid gland it has been learned that this gland is an indispensable organ, of vital importance in the bodily economy. Total removal of the diseased thyroid gland, a procedure formerly practised rather commonly, is no longer justifiable in view of recent experiences. The conservative methods that may be employed in the surgical treatment of goiter consist in intraglandular enucleation of the nodule out of the thyroid gland, unilateral extirpation of the gland, and resection of the gland.

Intraglandular enucleation (Porta, Socin) may be practised in the treatment of cystic goiter, as well as in that of circumscribed, well-limited goitrous nodules. The cutaneous incision is made over the greatest prominence of the tumor, and in accordance with its situation either longitudinally in the middle line of the neck, or transversely in an arched direction with its concavity upward (Kocher). After division of the skin and the platysma muscle the several lower hyoid muscles spread out over the thyroid swelling come into view and are either divided or retracted with hooks, in accordance with the direction of the cutaneous incision. The capsule of the goiter, as well as the healthy parenchyma of the thyroid gland overlying the goitrous nodule, is to be divided, when the nodule or the cyst is removed from its bed by blunt dissection and extirpated. Division of the nodule and isolated removal of its two halves constitute a modification of enucleation recommended by Kocher.

Unilateral Strumectomy.—A longitudinal cutaneous incision is made either in the middle line of the neck, or along the anterior border of the sternomastoid muscle; or an angular incision (Kocher) is begun at the level of the larynx upon the prominence of the sternomastoid muscle, passing transversely to the middle line of the neck, and thence downward to the suprasternal notch. The trans-

verse arched incision of Kocher's follows the line of the folds of the neck. After the superficial layer of the cervical fascia has been divided the anterior border of the sternomastoid muscle is isolated and retracted outward. The fascia further is divided in the median line, when the margins of the lower hyoid muscles are freed in the neighborhood of the larynx and divided transversely, so that the goiter is exposed throughout a large extent of its anterior surface. The capsule is divided and detached from the external aspect of the goiter, when the latter, if its outer boundary has been freed, is raised out of its bed and displaced from without inward. After the upper and lower poles of the tumor also have been isolated, the principal vessels of the thyroid gland, the superior and inferior thyroid arteries, and at the lower pole the middle thyroid vein also, are grasped and divided each between two ligatures. In ligating the inferior thyroid artery care must be taken to avoid the inferior laryngeal nerve, which lies in immediate proximity to the trunk of the artery. The thyroid isthmus, which is rendered accessible by lifting up the lower pole of the goitrous tumor, is freed from the anterior wall of the trachea by blunt dissection and secured with two ligatures, between which the isthmus is divided.

In practising resection of a goiter (Mikulicz) a portion of the gland is permitted to remain intact, generally together with the mouth of the inferior thyroid artery. The operation is performed in the manner previously described, the vessels being ligated at the upper pole. After the isthmus has been divided and the thyroid gland dissected also from the lateral aspect of the trachea, the gland is not completely enucleated, but clamped through its parenchyma above the lower pole, ligated in parts, and divided with the scissors in front of the ligatures. A portion of the thyroid gland in connection with the artery thus remains behind. The procedure has the advantage of avoiding the recurrent laryngeal nerve.

Tenotomy of the Sternomastoid Muscle.—This operation

is indicated in the presence of congenital *wry-neck*, for the correction of the abnormal position of the head. The sternomastoid is incised through an open wound at its tendinous attachment to the sternum or the clavicle. By rotating the head toward the unaffected side, the tendon of the sternomastoid is stretched tensely. An incision 3 or 4 cm. long is made parallel with the fibers of the muscle, in a situation corresponding with its sternal attachment. The tendon is exposed, isolated, drawn forward with a blunt hook, and divided with a single stroke of the scissors. If necessary, also, the clavicular attachment and the tensely stretched fascial portion are divided, until the head can be rotated toward the unaffected side without resistance. The cutaneous wound is closed by suture, and the head is fixed in a rigid dressing in the overcorrected position.

III. OPERATIONS ON THE TRUNK AND THE PELVIS.

Paracentesis Thoracis, Thoracotomy. — The thorax is opened by puncture or by incision when the presence of accumulations of fluid in the pleural cavity gives rise to threatening symptoms by reason of either their quantity or their character. In general the statement may be accepted that serous and hemorrhagic effusions are to be treated by puncture, and purulent exudates on the other hand by incision.¹ Either operation is therefore always preceded by exploratory aspiration of the pleural contents by means of a hypodermic or similar syringe. The operation of thoracocentesis is performed by the introduction of a trocar and cannula between two ribs into the pleural space, either permitting the fluid simply to escape, or aiding its removal by means of aspiration. If the cannula is so constructed that the aspiration of air can be avoided during the removal of the trocar, the first method of pro-

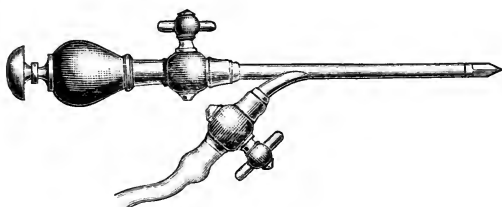


FIG. 215.—Billroth's trocar and cannula.

cedure meets all requirements. Billroth's cannula (Fig. 215) is provided with a lateral branch for the escape of the fluid, which can be controlled by a cock. To this

¹ If a hemorrhagic collection is very extensive and the life of the patient is seriously threatened, it is proper to open the thorax after rib-resection, and if the subsequent pulmonary collapse does not arrest the bleeding, endeavor to stop it by ligatures, by suture-ligatures, by packing a small pulmonary wound, or by filling the pleura with sterile gauze, to a point of counterpressure, and packing iodoform-gauze directly against the bleeding lung.—ED.

branch a rubber tube of suitable length is attached. The branch of the cannula in which the stilet is introduced is also provided with a cock, which is closed after the stilet has been removed. The patient is placed in the sitting posture, with the trunk bent somewhat forward. Except in the presence of a sacculated effusion, the trocar is introduced at the most marked convexity of the ribs in the fourth, fifth, or sixth intercostal space, or on the lower portion of the chest, between the seventh and ninth ribs, and close to the upper border of the lower rib. The operator marks accurately the point of introduction with the index-finger of his left hand. The branch of the cannula for the escape of the fluid is closed. Trocar and cannula are introduced vertically until disappearance of the resistance of the thoracic wall indicates that the point of the instrument has entered the pleural cavity. The operator now grasps the instrument with his left hand, removes the trocar, and permits the fluid to escape through the lateral branch of the cannula. The extremity of the rubber tube dips into a vessel containing antiseptic fluid. The flow should take place steadily and slowly. By this mode of procedure the entrance of air is avoided with certainty.

If the discharge of fluid ceases suddenly, the flow can be facilitated by changing the position of the cannula, if the obstruction be due to approximation of the lung. Occlusion of the tube by coagula may be overcome by the introduction of a blunt probe.

The evacuation of the fluid can be better controlled when with puncture is conjoined aspiration of the pleural exudate. In place of the trocar and cannula a sharp hollow needle is employed, which is connected by means of a tube with the mouth-piece of an air-tight syringe (Dieulafoy's aspirator). By withdrawing the piston of the syringe, the air in the glass cylinder can be sufficiently exhausted and the fluid in this way aspirated. Fluid can by this means still be evacuated when there is no excess of pressure in the pleural cavity.

Permanent siphonage of pus from the pleural cavity following puncture (Playfair and Bülow) permits of the gradual discharge of the fluid. Puncture is made in the axillary line with a strong trocar, and followed by the introduction of a rubber tube into the pus-cavity. The tube is fixed in the wound and connected by means of an intermediate segment with a long tube dipping into a vessel at a lower level containing antiseptic fluid.

Thoracotomy, opening of the pleural cavity by incision, is indicated when the pleural exudate is purulent in character. Unless the exudate be sacculated or circumscribed, the incision is made in the fifth or sixth intercostal space over the greatest convexity of the ribs. To avoid injury of the intercostal vessels the knife is introduced close to the upper border of the rib, dividing the two layers of intercostal muscles, the endothoracic fascia, and the pleura throughout the entire extent of the incision. By the introduction of a rubber tube into the wound, drainage of the pleural cavity will be established. To permit of more convenient access and to render possible adequate drainage, resection of from 3 to 4 cm. of a rib in its continuity is recommended. The incision is made in the axillary line between the fifth and the sixth rib, or on the back in the region between the seventh and the ninth rib. Under these circumstances the cutaneous incision is made directly over the rib, dividing its periosteum throughout a distance of 5 or 6 cm. The periosteum is reflected upward and downward by means of a raspator from the anterior surface of the rib, and then with especial care from its posterior surface. The portion of the rib thus exposed is resected throughout the given extent by means of bone-shears (costal shears of Gluck) or of the wire saw. The uninjured pleura is incised, the purulent contents permitted to escape, and drainage established. From a cutaneous incision, in order to obtain free access, two ribs may be exposed and resected in the manner described (Fig. 216). If in the presence of disease of the pleura, with contraction of the lung or a pleural fistula, the empyema cannot

be made to close on account of the rigidity of the thoracic wall, resection of a series of ribs is a suitable procedure in order to render the wall of the chest more yielding.

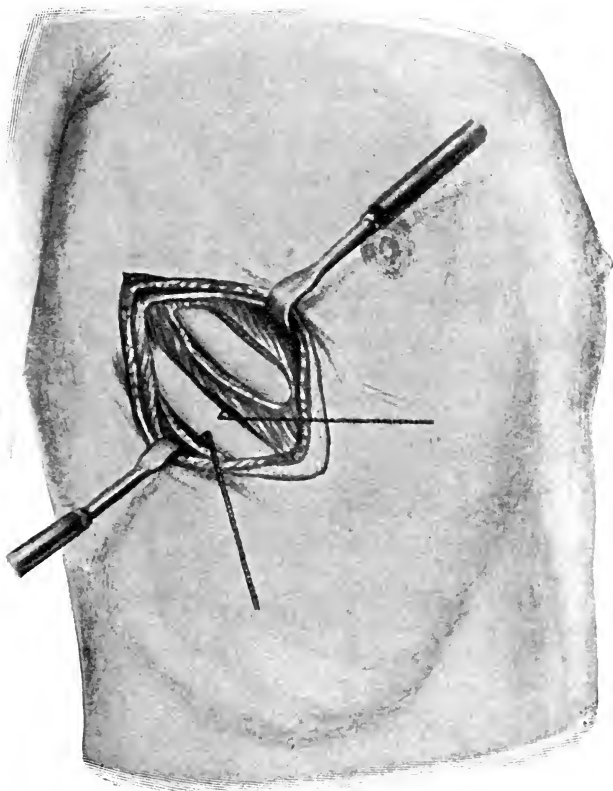


FIG. 216.—Resection of the ribs.

The possibility thus established of approximating the parietal and visceral layers of the pleura renders the conditions favorable for cessation of the long-continued and tedious suppurative process.

Estlander resects for this purpose from five to seven ribs in the axillary line throughout an extent of from 3 to 10 cm., by means of a long, vertical incision. The pleura is freely exposed within the range of the large opening made. Thoracoplasty by the method of Schede is a more radical procedure. In this operation a large flap of soft parts with its base above is made from the tissues of the chest. The upper extremities of the incisions lie: in front, in the axillary cavity; posteriorly, between the vertebral column and the scapula at the level of the second rib. Within the range of the dissected flap reflected upward, all the bony ribs are resected throughout their entire extent up to the tubercle. After free opening of the pleura and its toilet the flap of soft parts is placed over the lung and fixed in this position by means of a dressing. Delorme practises temporary resection of the ribs, incises the pleura over the contracted lung, and, if the lung can be distended, replaces the flap in the chest-wall.

Puncture of the pericardium is indicated in the presence of hemorrhagic and serous effusions in this sac, if these become so great as to interfere mechanically with the action of the heart. The trocar is introduced in the fourth or the fifth intercostal space, 3 or 4 cm. from the left border of the sternum.

Opening of the pericardium is indicated if exploratory puncture discloses the presence of a purulent effusion in this cavity. A transverse incision is made in the third, fourth, or fifth intercostal space, to the left of the sternum. With careful dissection advance is made toward the depth (ligation of the internal mammary artery), and the exposed pericardium is snipped throughout a small extent with scissors. Ollier and Durand make the incision from the middle line over the fifth left costal cartilage, which they resect.

In order to expose portions of lung for incision or resection, on account of the presence of tumors, abscesses, gangrenous cavities, the chest-wall is, after accurate local-

ization of the focus of disease, incised in this situation, and then resection of one or of several ribs is practised. If the layers of pleura are adherent over the focus of disease, the incision may be made directly into the lung. In cases in which this condition is not present, the operation is performed in two stages, adhesion of the two layers of pleura being brought about by means of caustics (paste of zinc chlorid—Quincke) before the incision is made. After resection of the ribs and division of the intercostal muscles, the paste is introduced into the wound and renewed a number of times, after which, in the course of about four weeks, the lung may be attacked without danger of opening the pleura.

Ligation of the Internal Mammary Artery.—The cutaneous incision is made in the third or fourth intercostal space from the border of the sternum outward for a distance of 4 or 5 cm. The skin, the subcutaneous connective tissue, the pectoralis major, and the internal intercostal muscle are divided throughout the extent of the incision. Lying in front of the pleura, in the angle between the rib and the sternum, is the internal mammary artery, which follows the axis of the body and is accompanied by two veins. The vessel can readily be isolated from the loose connective tissue. Esmarch makes a longitudinal incision alongside the sternum and enlarges the field of operation by resection of a costal cartilage (Fig. 217).

Removal of the Mammary Gland.—*Amputation of the Breast.*—Circumscribed tumors of benign character can be readily enucleated from the glandular tissue of the breast. If the tumor be superficial, the cutaneous incision is made longitudinally in the direction of the radius of the breast, and if the growth be more deeply seated, a semicircular incision is made corresponding with the lower boundary of the gland. Through the last-named incision tumors of considerable size (adenomata, cystomata) also may be removed from the breast without leaving disfiguring cicatrices. The entire breast also can be ampu-

tated in this way with preservation of the skin. If removal of the breast, together with the overlying skin, is necessary, the mammary gland is surrounded by two incisions, forming an oval whose longitudinal axis extends from without and above, inward and downward, from the

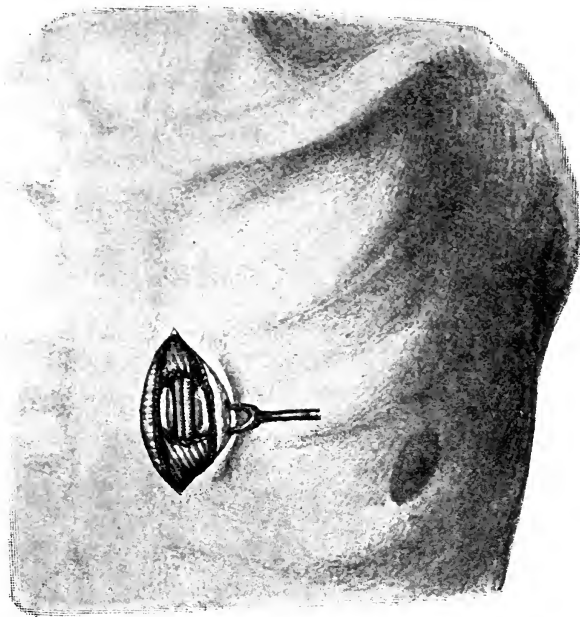


FIG. 217.—Exposure of the internal mammary artery. The cartilage of the third rib is resected close to its sternal attachment. The pectoral muscle is divided. In the upper and lower angles of the wound the stumps of the intercostal muscles are visible. In the depth of the wound the mammary artery can be seen, accompanied by a vein.

anterior axillary fold, almost to the ensiform cartilage (Fig. 218). The skin is detached up to the margin of the breast, and this is raised and dissected from the pectoral muscle. The cutaneous wound can be closed by linear suture.

In the presence of carcinoma of the mammary gland all the axillary fat, with the glands, must be removed, together with the breast, in every case, whether the adjacent lymphatic glands are enlarged or not. The breast is extirpated in connection with the overlying skin and the two pectoral muscles (Halsted, Rotter, Joerss). In practising Kocher's method of procedure the structures of the axillary cavity can be exposed with extreme freedom. In spite of removal of the pectoral muscles, the functional results also are good.

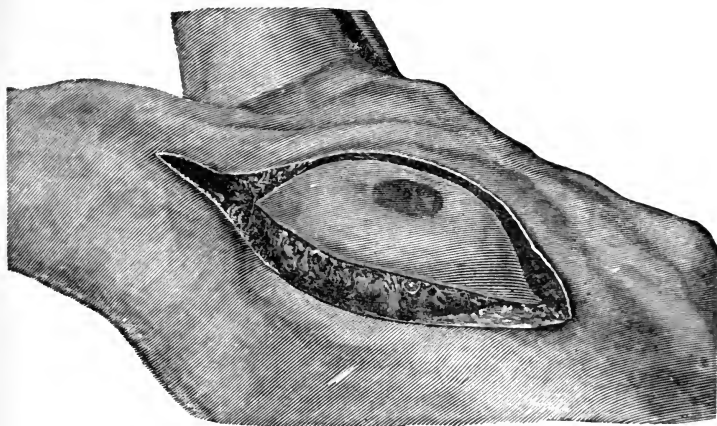


FIG. 218.—Amputation of the breast: cutaneous incision.

The cutaneous incision (Fig. 219) begins at the clavicle, close to the insertion of the pectoral muscles, divides these transversely, and passes in a curved direction along the lower boundary of the mammary gland to the ensiform cartilage. A second curved incision passes from this point over the breast and meets the first. Next the attachments of the pectoral muscles to the humerus and to the coracoid process are completely divided transversely. If the stumps of the muscles are separated, a wide entrance to the axillary cavity is provided.

Plate 28.—Amputation of the Carcinomatous Breast, I.

The pectoral muscles (*Pm*, *Pmi*) are divided transversely. The structures of the axillary cavity, the axillary artery (*A*), the axillary vein (*V*), the roots of the median nerve (*M*), are exposed. The axillary fat, together with the lymphatic glands, is lifted out of the axillary cavity and remains in connection with the mammary gland, which has fallen downward. *Ss*, subscapular artery and vein ; *Tl*, long thoracic nerve.

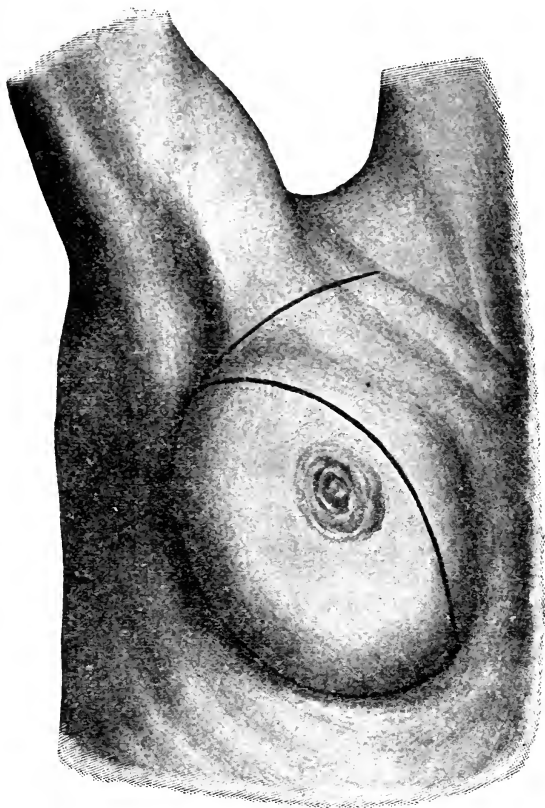
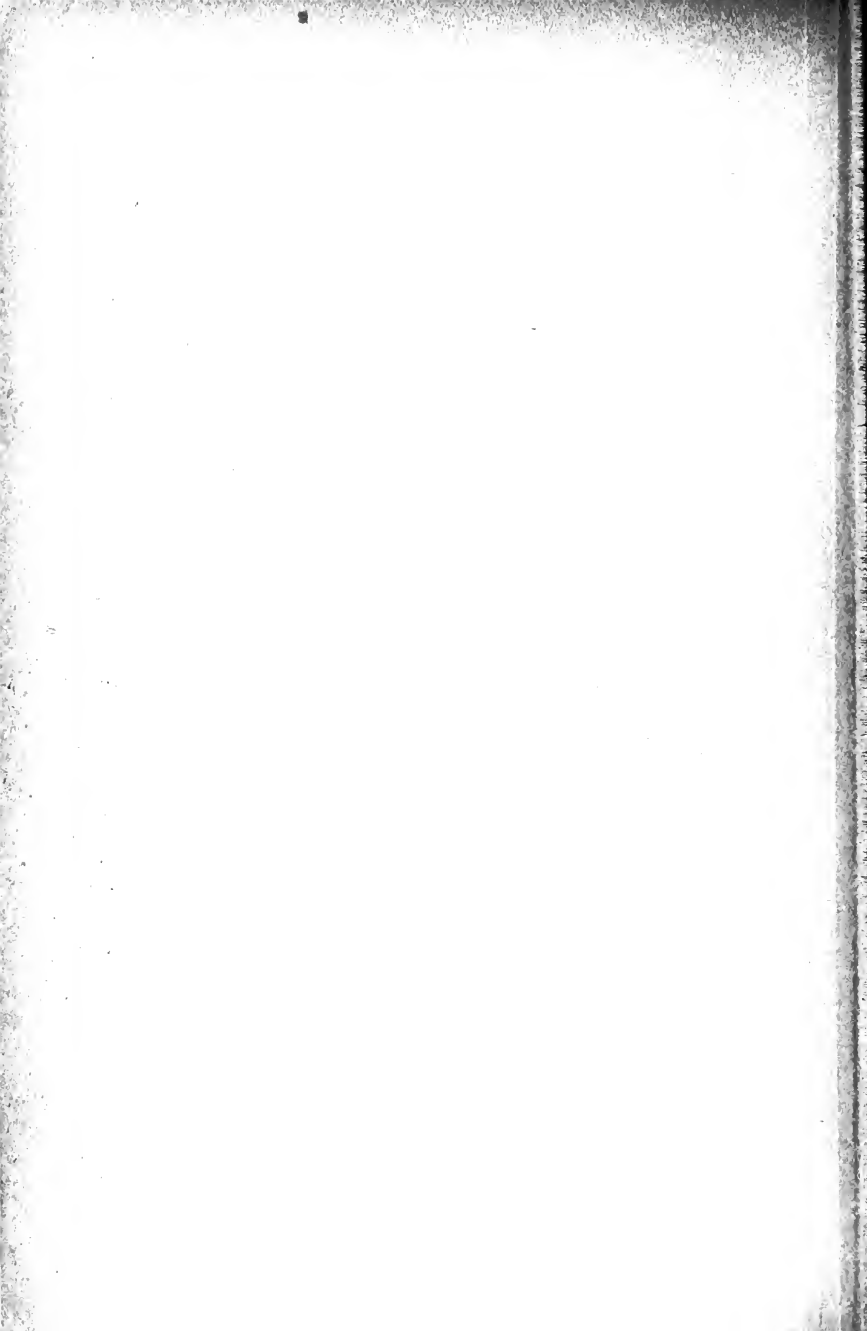


FIG. 219.—Cutaneous incision (method of Kocher) for amputation of the mammary gland, together with the axillary glands and the pectoral muscles.

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Beginning at the great vessels and dissecting from above downward, the fat of the axillary cavity is removed. The vascular cords passing from the great vessels to the packets of glands and the thorax are distinctly visible. They are isolated at their origin and divided between two ligatures. These vessels are the superior thoracic artery and the long thoracic artery. In the process of further dissection of the fat the posterior axillary fold is exposed and the subscapular and the latissimus dorsi muscles, and, at the border of the scapula, the large subscapular artery, accompanied by veins and nerves, become visible (Plate 28). Frequently ligation of the subscapular artery and vein or of the posterior circumflex artery and vein is also necessary.

Küster has called attention to the importance of protecting the long thoracic nerve from injury. If it prove impossible to free the axillary vein fully from glandular tissue, it often becomes necessary under such conditions to sacrifice a portion of this vessel. After the application of ligatures the vein is resected throughout the necessary extent and removed together with the glands. The insertions of the pectoral muscles to the ribs, and which are reached by dissecting downward, are separated from the chest-wall and reflected toward the sternum. This separation is continued in the course of the posterior curved incision, which is successively deepened, until the whole of the glandular tissue of the axilla and both pectoral muscles, together with the mammary gland, constitute a mass detached from the thorax, which is removed as a whole (Plate 29). From the upper extremity of the incision the region below the clavicle can yet be inspected. The incision is prolonged over the clavicle, and, if necessary, even temporary division of the clavicle (Madelung) is practised. In this way the supraclavicular fossa is rendered accessible. The axillary portion of the wound can always be completely closed by suture, at times, it is true, with stretching of the skin, also the lower portion of the wound (Fig. 220). Should this not prove to be

Plate 29.—Amputation of the Carcinomatous Breast, II.

The mammary gland, together with the axillary glands and the pectoral muscles, is freed from the thorax and reflected toward the middle line. The exposed thoracic wall, with the ribs, the intercostal muscles, and the digitations of the serratus muscle (*Sr*), come into view. Posteriorly is the margin of the scapula with the subscapular muscle (*Ss*), and, further outward, the exposed latissimus dorsi muscle (*Ld*).

the case, the unclosed portion, which often is not more than an inch in diameter, is left to close by granulation or

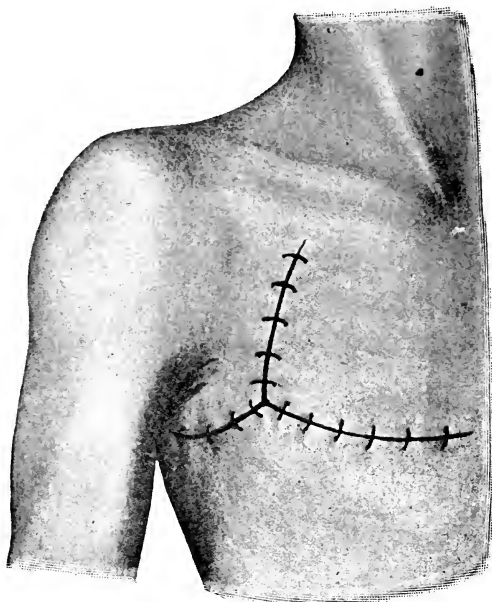


FIG. 220.—Cutaneous suture after amputation of the breast.

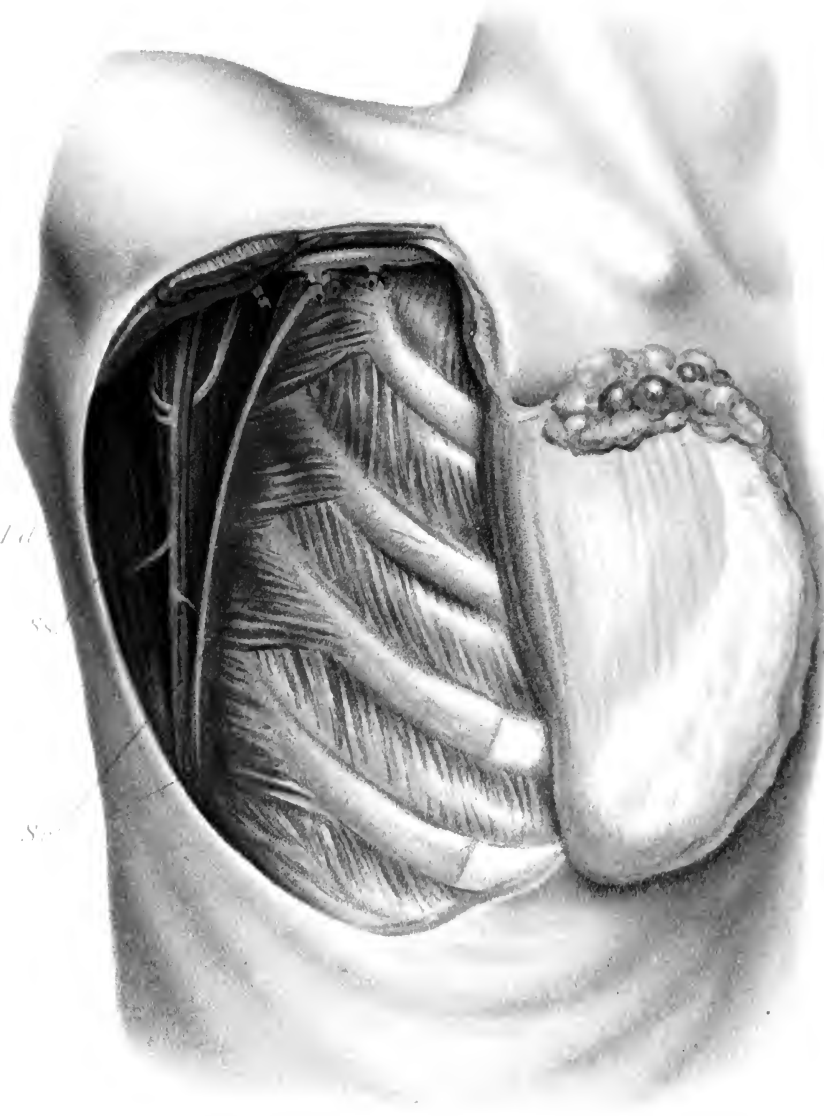
it is covered by transplanted flaps of skin, according to the method of Thiersch.

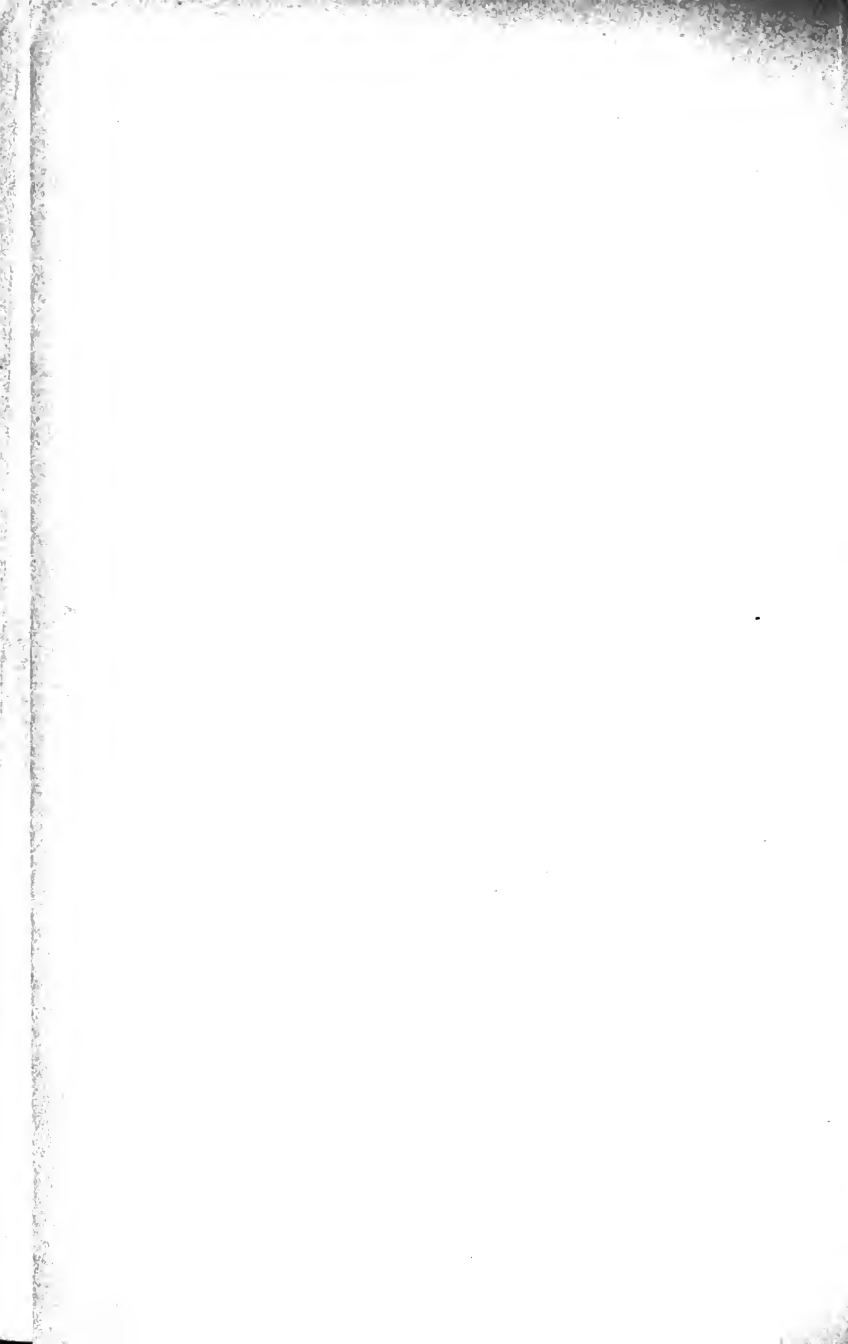
Abdominal Puncture.—The abdominal cavity may be opened by puncture to effect evacuation of fluid accumula-

Id.

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tions, either free within the peritoneal cavity, or sacculated, or contained within cysts. If the fluid be free, the point of *Monro*, that is, a point midway between the umbilicus and the left anterior iliac spine, is, as a rule, selected as the situation for puncture. *Trzebizky* has demonstrated that in a small proportion of cases the epigastric artery or one of its branches may be injured in performing puncture by this method. If, however, the trocar is introduced into the outer half of the line between the umbilicus and the superior iliac spine, the possibility of this unpleasant occurrence is safely avoided. The recommendation to make the puncture upon the left side of the abdomen is not of primary importance. If the liver be enlarged, the puncture will be preferably made upon the left side. Enlargement of the spleen of any considerable degree will justify making the puncture upon the right side. The puncture may further be made in the *linea alba*, midway between the umbilicus and the symphysis pubis. The selection of the point of puncture in the presence of cysts and of sacculated exudates will be governed by the situation of the accumulation of fluid.

In performing puncture of the abdomen a straight trocar and a cannula with a lateral branch are employed. The patient occupies a partial lateral position or the upper portion of the body is elevated. Before the trocar is introduced it should be determined by careful percussion that the intestine is not adherent to the abdominal wall at the point where the puncture is to be made. The index-finger of the left hand is placed at the point of puncture, and the trocar is introduced vertically through the abdominal wall, then grasped with the left hand, while the right removes the trocar. By means of a tube attached to the lateral branch of the cannula the fluid is permitted to escape slowly into a suitable receptacle. If the intra-abdominal pressure falls, the escape of the fluid is favored by compression of the abdomen with the hand or by tightening a many-tailed bandage around the abdomen. It is an old rule never to permit the escape of all the

Plate 30.—Exposure of the External Iliac Artery.

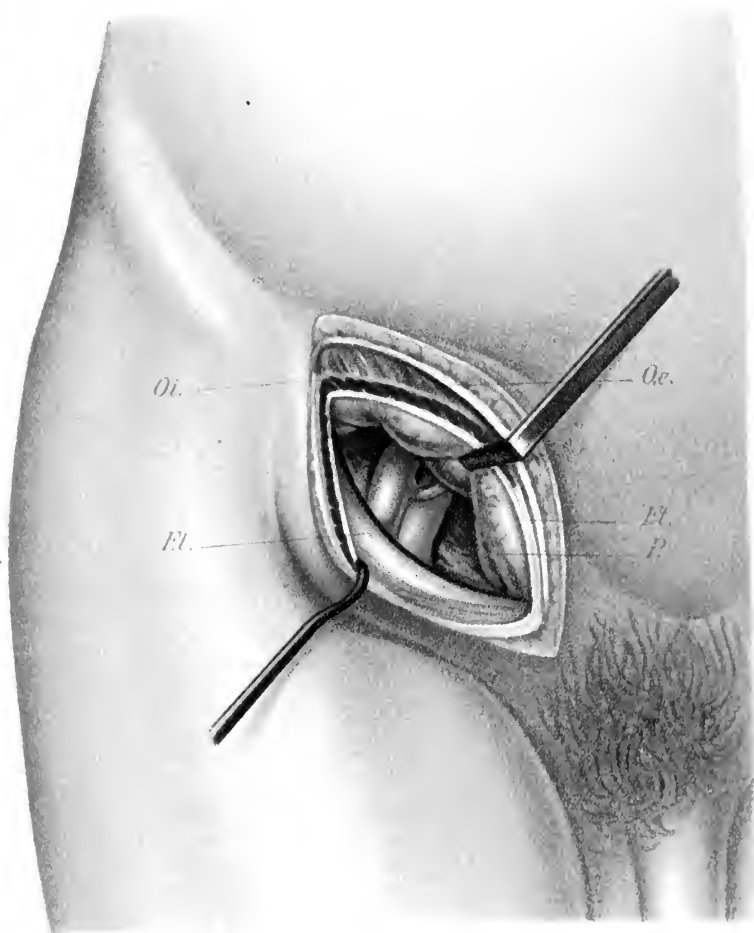
There are divided the aponeurosis of the external oblique muscle (*O. e.*), the fibers of the internal oblique (*O. i.*), and the transversalis fascia (*F. t.*); the peritoneum (*P*) is separated by blunt dissection and raised up; the iliac artery and vein are exposed in the subserous space.

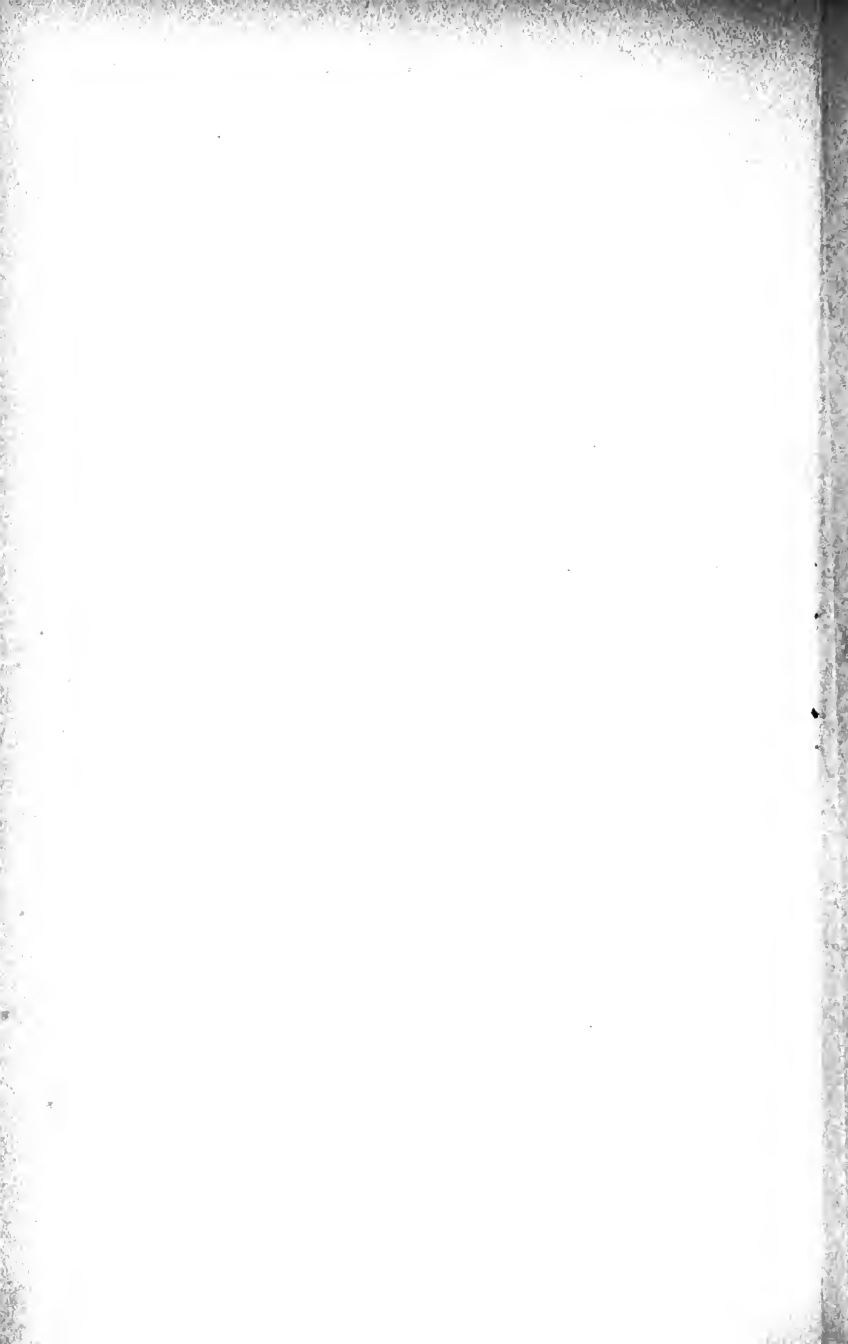
fluid contained within the abdominal cavity. The trocar is therefore removed at a time when a certain amount of fluid is yet present, and the wound is closed with a suitable dressing.

Ligation of the Iliac Artery.—At the level of the fourth lumbar vertebra the aorta divides into the two iliac arteries, each of which in turn divides at the sacro-iliac articulation into two branches, the external and internal iliac arteries. The external iliac artery, the abdominal portion of the femoral, passes along the outer side of the corresponding vein along the psoas muscle to the opening beneath Poupart's ligament for the vessels. The internal iliac artery, also known as the hypogastric, passes from the sacro-iliac symphysis down into the pelvis, to supply the organs of this cavity, as well as the gluteal muscles and the genitalia, with blood.

Ligation of the External Iliac Artery.—The artery is exposed in the subserous space just prior to its entrance into the opening for the vessels. The cutaneous incision is made parallel with, and over the middle of, Poupart's ligament, and the fascia of the external oblique muscle; the fibers of the internal oblique and transversalis are divided in the direction, and throughout the extent, of this incision. After division of the transversalis fascia the subserous fat and the peritoneum are exposed to view. The peritoneum is separated by blunt dissection from Poupart's ligament and the pelvic margin, after which the external iliac vessels surrounded by loose connective tissue become visible upon the floor of the wound. The artery (the vein lies to its inner side) is isolated by blunt dissection with the aid of two anatomic forceps (Plate 30).

In ligating the internal iliac artery the cutaneous in-





cision passes from the apex of the last rib vertically downward to the crest of the ilium and along this almost to the anterior superior iliac spine. The layers of the abdominal wall and the transversalis fascia are divided, the peritoneum separated by blunt dissection from the iliac fossa and displaced toward the median line by means of broad spatulæ or the palm of the hand. Between the iliac and psoas muscles the external iliac artery is visible and can be followed in a proximal direction as far as the sacro-iliac symphysis, where the internal iliac artery is accessible as it branches off toward the pelvis and can be isolated for ligature. The vein lies to the inner side of the artery. The mode of procedure just described serves also for exposing the common iliac artery.

The manner of exposing the iliac vessels constitutes in general the mode of procedure in accordance with which the structures of the subserous space are reached. The incision for ligation of the internal iliac artery exposes the kidney and the ureter in its course. In the same way it is possible, with conservation of the peritoneum, to evacuate accumulations of pus in the subserous space (psoas abscess, paratyphlitic abscess, parametric abscess).

If after opening the abdominal cavity by celiotomy the parietal peritoneum upon the posterior wall of the abdomen is divided and in this way the retroperitoneal space is exposed, the procedure is designated transperitoneal exposure of the iliac artery, of the kidney, of the ureter, etc. Under these conditions the peritoneum must be divided at two corresponding points on the anterior and the posterior abdominal wall.

Celiotomy.—Opening of the abdominal cavity through incision of the abdominal wall is designated celiotomy. The procedure is a preliminary one in the performance of intraperitoneal operations of all kinds. The abdominal incisions are sometimes made longitudinally, sometimes more or less obliquely, and sometimes even transversely. Longitudinal incisions are made either in the linea alba or along the outer border of the rectus abdominis muscle.

In the epigastrium and the hypogastrium, both oblique incisions parallel with the costal margin, or with Poupart's ligament, and longitudinal and transverse incisions are employed. The incision into the linea alba is indicated

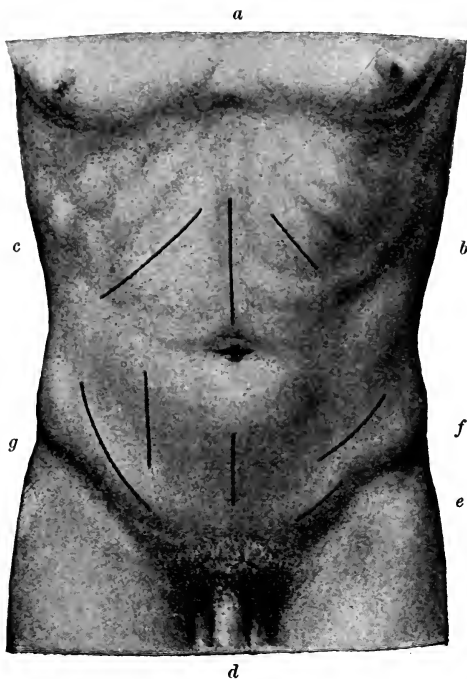


FIG. 221.—Abdominal incisions: *a*, longitudinal incision for operations on the stomach; *b*, incision for gastrostomy; *c*, incision for operations on the gall bladder; *d*, incision for epicystotomy; *e*, incision for ligation of the external iliac artery; *f*, incision for colotomy; *g*, incisions for exposure of the cecum and the vermiform appendix.

in the presence of large formations occupying the abdominal cavity. The incision is made below the umbilicus when the pelvic organs are the object of attack. Through the epigastrium access is gained to the stomach, or upon

the right side to the liver and the gall-bladder. An incision is made into the right iliac region when it is intended to reach the cecum or the vermiform appendix, and into the left to reach the descending colon or the sigmoid flexure (Fig. 221). In the performance of intraperitoneal operations the patient is either placed horizontally or the body is placed upon an inclined plane with the head at the lowest and the pelvis at the highest level (Trendelenburg's position, Fig. 222). This position affords a clear view of the arrangement of the pelvic organs after the abdominal cavity has been opened, the intestines sinking down toward the epigastrium in the concavity of the diaphragm. The position therefore permits careful inspection of the abdominal viscera and protects the intestines from extrusion during the course of the operation.

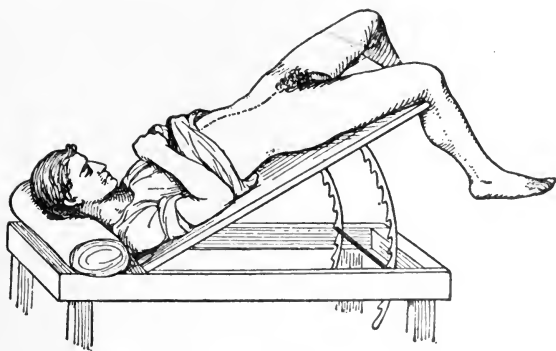


FIG. 222.—Trendelenburg's position.

Mode of Making the Incision through the Abdominal Walls.—Through the linea alba, as in other portions of the abdominal wall, dissection is effected layer by layer with the scalpel. The skin and the subcutaneous connective tissue are divided and access is gained to the dense fibrous upper layer of the sheath of the rectus muscle or between the two rectus muscles. As a rule, the median

borders of the recti muscles are exposed within the wound. After division of the posterior layer of the sheath of the rectus a layer of loose connective tissue comes into view, and in obese persons a layer of fat, often of considerable extent, lying directly upon the peritoneum. All fatty tissues are carefully divided by blunt dissection with two pairs of forceps. A fold of parietal peritoneum is picked up and opened at one point, and the incision is enlarged above and below in the direction and throughout the extent of the superficial wound by means of scissors or a blunt-pointed knife. Longitudinal, oblique, or transverse incisions in the epigastrium extend also, like those in other regions, successively through the layers of the abdominal muscles to the subserous fat and the peritoneum. A fold of the parietal peritoneum is picked up with two pairs of forceps and snipped with scissors, and the incision is enlarged in the manner already described. The closure of the abdominal wall should be firm and resistant; the resulting cicatrix should display no tendency to ectasis and the formation of ventral hernia. Suture of the wound should be effected with silk or absorbable material introduced in tiers. In the linea alba the deepest row of sutures includes the peritoneum only, care being taken that smooth serous surfaces are brought in approximation. The second row of sutures includes the rectus muscle, together with its anterior fibrous sheath; several deep sutures secure the approximation of the muscles; more superficial ones passing through the anterior sheath approximate accurately the aponeuroses. The most superficial layer of sutures unites the skin in the customary manner. In the same way abdominal wounds in other situations are closed by three tiers of sutures. The deepest row unites the peritoneum, the middle the muscle and the aponeurosis, and the upper the skin.

Operations on the Intestine.—Suture of the Bowel.
—Enterorrhaphy may be necessary to unite by suture either a penetrating or a non-penetrating wound of the intestine, or the completely divided bowel throughout its

whole circumference. The suture should in general be so applied that the resistant layers of the intestinal wall, such as the muscularis, are brought in apposition. Over these layers broad folds of serosa should be approximated by suture, to facilitate rapid primary union.

In all operations the bowel is brought out through the abdominal wound and suitably protected against cold and infection. In order to prevent the escape of intestinal contents the intestine is grasped, centrad and peripherad of the wound to be united, with clamp-forceps, with the fingers, or with bands of sterilized gauze.

Linear wounds of the intestine, as well as of the stomach, are united in such a manner that all the divided layers can be included within the suture. It is unimportant whether the mucous membrane be included or not, while it is highly important that broad layers of the muscularis should be approximated. The sutures are applied from either the serous surface or the lumen of the bowel. In the first instance the sutures are to be tied externally; in the latter, internally. When the suture has been thus applied throughout the whole extent of the wound, further closure is effected by approximation of folds of serosa (Lembert suture). Surfaces of serous membrane from 4 to 5 mm. wide are brought in apposition by introducing the needle a short distance from the margin of the wound and bringing it out close to the margin, and repeating the process in reversed order upon the other side. When the ends of the suture are tied, the serous layer on either side is raised in folds, so that two broad surfaces of peritoneum are brought into approximation. In order to give greater stability to this suture the subserous tissues and even a portion of the muscularis are taken up with the serous layer. The folds thus formed are thicker, while a considerable extent of surface is brought in apposition (Plate 31).¹

Both rows of intestinal suture may be applied in the form of interrupted sutures or as a continuous suture.

¹ It is maintained by Halsted that the tough submucous coat must be caught up in order to prevent cutting out of the thread.—ED.

Plate 31.—Suture of the Bowel.

FIG. 1.—Intestinal sutures introduced from the serous surface: *a*, involving all layers with the exception of the mucosa; *b*, Lembert's sero-serous suture.

FIG. 2.—Circular intestinal suture, applied from the lumen of the bowel and including all layers.

If a divided portion of bowel is to be united throughout its circumference, similar principles may be followed. Two rows of closely applied sutures will suffice. The first includes all the layers of the bowel, and is intended to fix the cut surfaces in apposition; the second brings the serous surfaces together. The operator should see that corresponding portions of the circumference are brought accurately in contact with one another. To this end a suture is applied at the mesenteric attachment of the bowel and also one at a corresponding point on the opposite side of the periphery, both involving all the layers of bowel. In this way the entire circumference is divided into two equal parts. The margins of that portion most removed from the operator are first united, the sutures being passed from the mucous surface and being tied from the lumen of the bowel (Plate 31). This suture includes all the layers of the bowel. The margins of the wound closest to the operator are first united by sutures passed from and tied upon the serous surface. In order to secure primary union of the intestinal wound within a short time a second row of sero-serous (Lembert) sutures is applied over the first. Under these circumstances, also, it is advisable to include with the serous layer a portion of the muscular layer, as in this way the serous folds are made firmer and can be brought into closer approximation.

If portions of intestine of unequal lumen are to be united, the narrower portion of bowel can be divided obliquely (Billroth), and in this way the desired adaptation secured. Many attempts have been made to replace the time-consuming suture by fixation of the intestinal

Fig. 1.

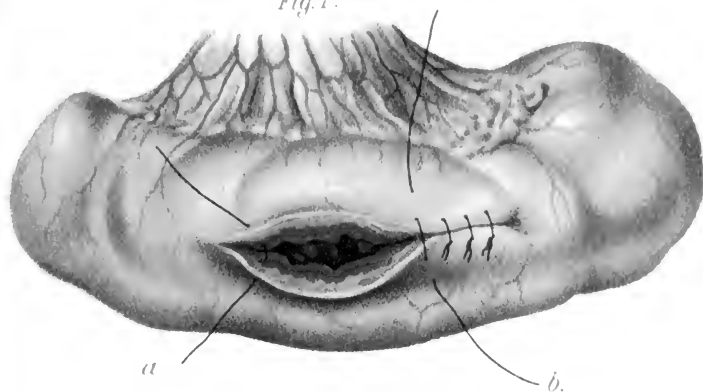
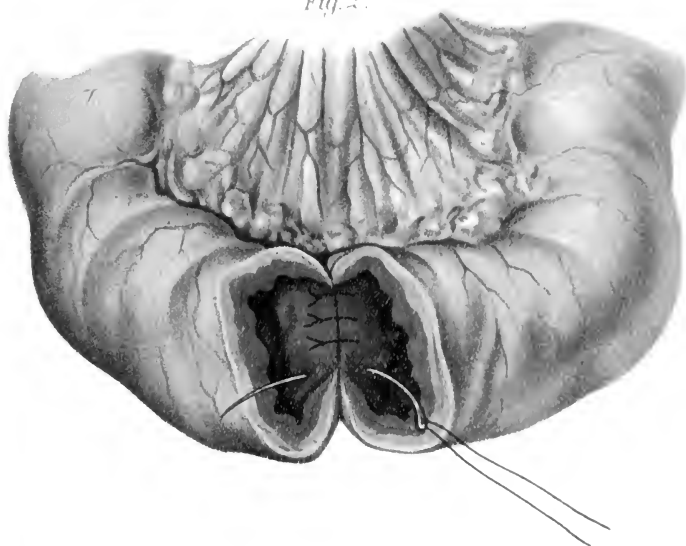
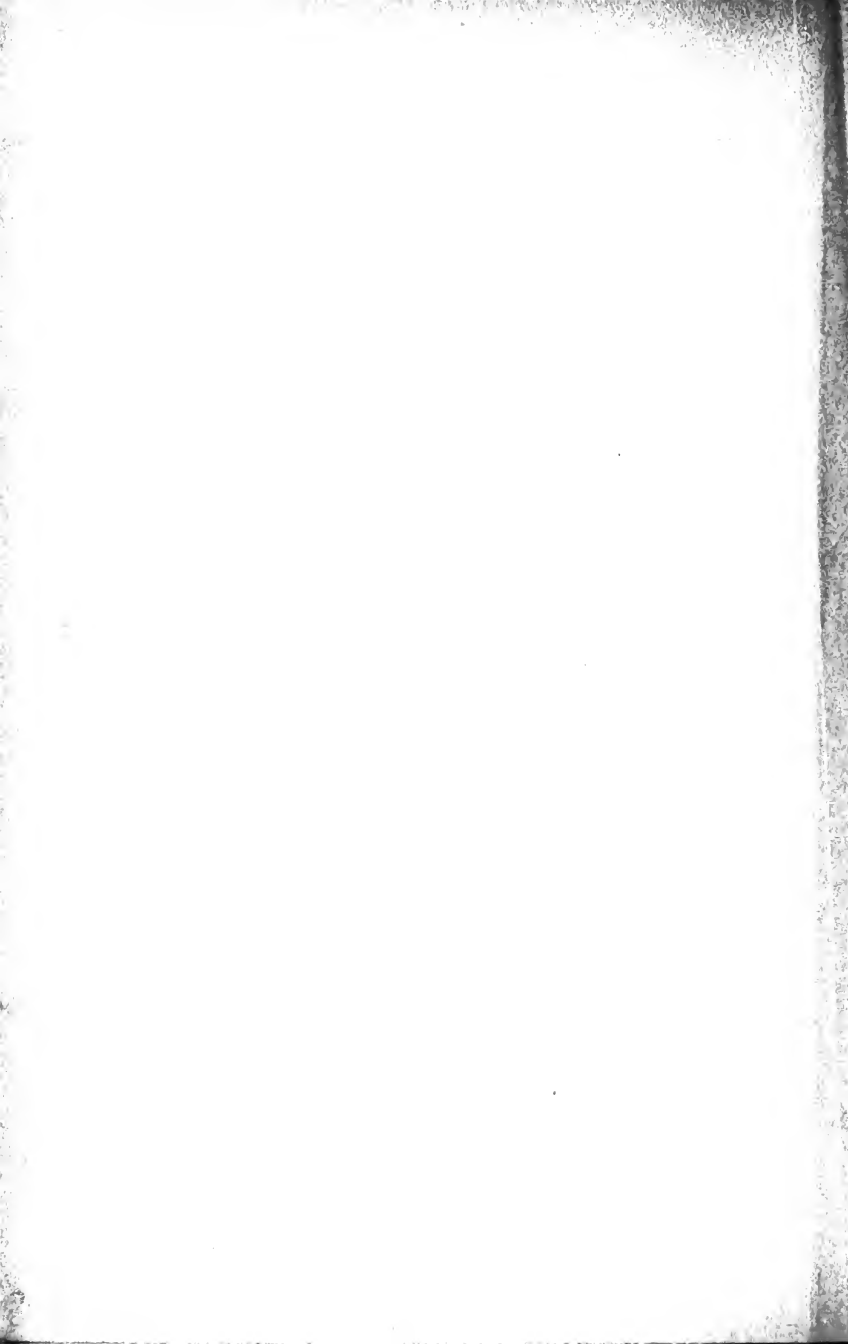


Fig. 2.





stumps for restoration of continuity over a tubular body by means of a ligature. Murphy's intestinal button was the first device that permitted a practical application of this method. This ingenious device consists of two capsules made of light sheet-iron and nickel-plated and provided with a hollow cylinder internally and a slight shoulder externally (Plate 32). The one capsule can be readily pushed into the other with the fingers, when by reason of a clamp-like arrangement they remain thus in secure apposition. The transversely divided portions of intestine are picked up by a spiral purse-string suture (Fig. 223), which is drawn together and tied after the button has been introduced into the intestine. After the second portion of the intestine has been similarly treated the two halves of the button are pushed one into the other and pressed together, when they remain permanently in this relation (Plate 32). In this way the stumps of intestine are brought in apposition by means of broad surfaces of the serosa. The small openings in the sides of the button serve as an outlet for the escape of secretion from the included portion of bowel, while intestinal contents and gas can escape through the larger central opening. When the clamped portions of the intestine are necrosed, at the end of one or two weeks, firm union of the bowel will have taken place. The button is then freed and escapes with the intestinal contents.

Murphy's button undoubtedly renders possible rapid accomplishment of exact union of divided intestinal lumen. Accidents occasionally occur in consequence of perfora-

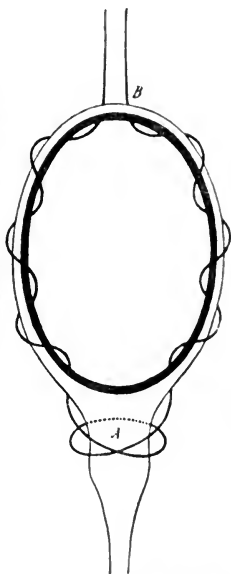


FIG. 223.—Murphy's purse-string suture. *A*, Mesenteric attachment.

Plate 32.—Union of Intestine by Means of the Murphy Button.

FIG. 1.—*a, b*, the two halves of the button; *c*, the two halves of the button clamped together; *d*, the mode of introducing the sutures for holding each half of the button in place.

FIG. 2.—Completed union of the intestine by means of the Murphy button. The slit in the mesentery has been closed by linear union.

tion, although there is no security against this even in the application of sutures and with thorough control of the technic. When speedy completion of the operation is of vital importance, the button may be employed, but in other cases the operator may exercise his own preference as to which of the two methods he will select.

At times it becomes necessary to effect blind closure of a divided extremity of intestine, by means of suture, as, for instance, in excluding portions of the bowel, in the establishment of lateral anastomosis after resection of the bowel, in the performance of one variety of colostomy, etc. The closure is always effected in two tiers; the intestinal walls can be applied to each other and be united in a linear manner at the cut surface by means of sutures passing through all layers, and applying a Lembert suture over these; or the transverse section of the intestine is surrounded with a purse-string suture including all the layers, and which is drawn together to effect closure. The ligated extremity of the intestine is invaginated, and closure is secured by means of seroserous sutures. Finally it will be sufficient if, in place of the purse-string suture, the intestine is surrounded with a ligature and is divided transversely upon the distal side. The mucous membrane projecting from the cut surface is excised, the stump invaginated, and closed tightly with seroserous sutures (Figs. 224 and 225).

Entero-anastomosis.—This designation is applied to the surgical establishment of an opening of communication between two different portions of intestine. By this means a new path for the intestinal contents is afforded,

Fig. 1.

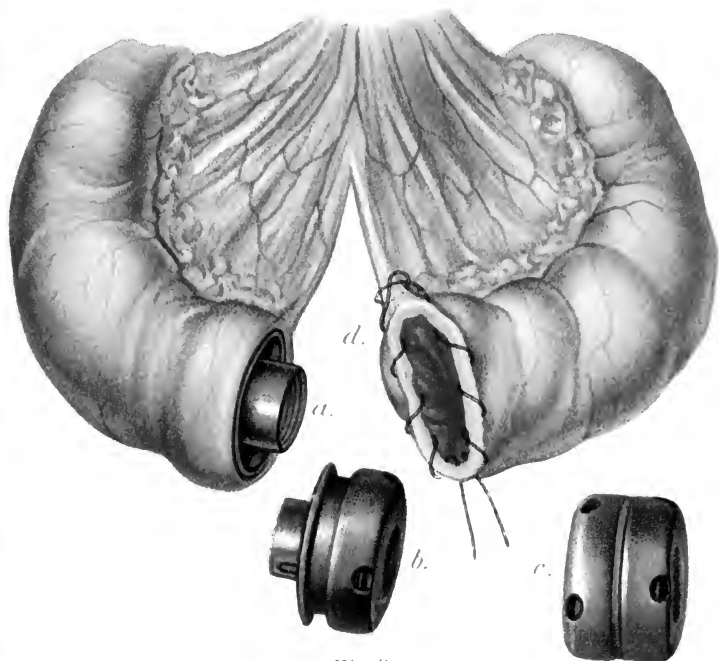
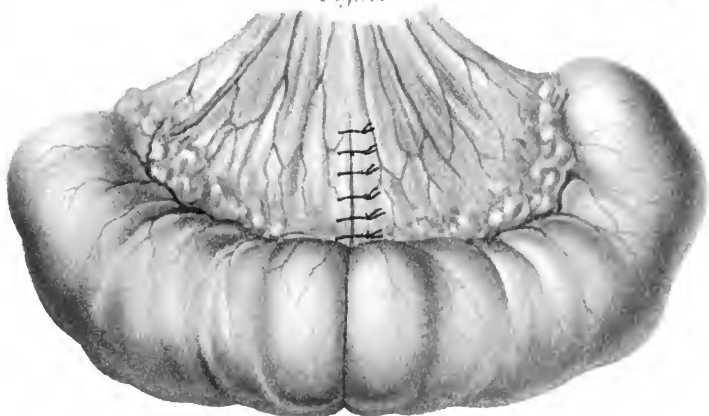
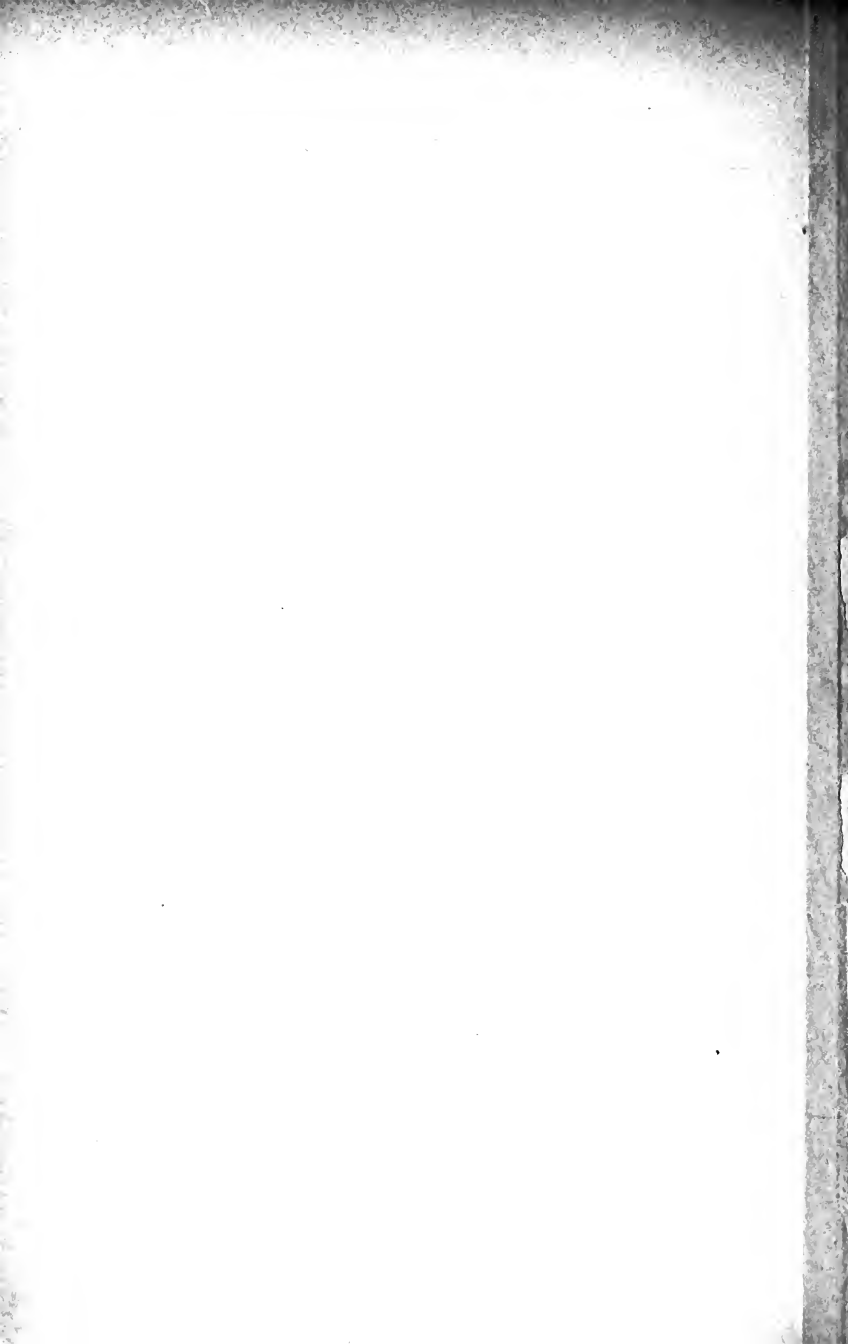


Fig. 2.





with the avoidance of a portion of the bowel ; so that diseased portions of intestine may be placed out of function by the establishment of the anastomosis. With this object in view the operation is indicated in the presence of changes in the intestinal wall that have given rise to

TERMINAL CLOSURE OF A PORTION OF INTESTINE.

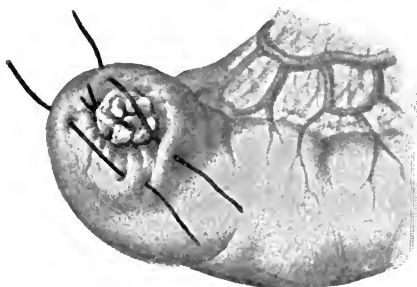


FIG. 224.—The extremity tied with a ligature. Lembert sutures are introduced.

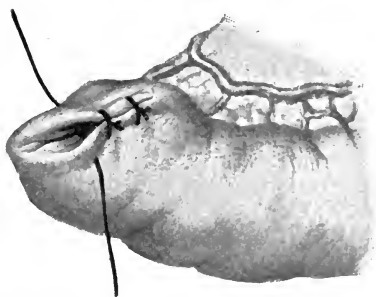


FIG. 225.—The ligated extremity is invaginated and closed over by Lembert sutures.

stenosis of the lumen, and for the relief of which radical removal by means of resection is either impossible or appears inopportune (tumors, tuberculous disease, cicatricial stricture of the intestine). The establishment of an anastomosis may, further, be undertaken advantage-

Plate 33.—Intestinal Anastomosis.

FIG. 1.—The ends of the intestine are united by linear serous sutures opposite the mesenteric attachment.

FIG. 2.—Both ends of the intestine are opened. The posterior half of all the layers is attached by circular suture.

ously in place of circular suture of the intestine after resection. The two stumps of intestine are closed at their extremities by suture (p. 305), then placed side by side, and communication is established between them by means of a longitudinal opening in each. In this way broad surfaces may be sutured together, without, as in the case of circular suture, narrowing the lumen of the intestine. Further, in the application of this form of suture, inequality in the size of the lumen of intestine to be united is without significance. Finally, the establishment of an anastomosis can be accomplished more quickly than circular suture.

Hacker has amplified the indications for intestinal anastomosis, and recommends this procedure in the presence of penetrating wounds of contiguous portions of intestine, as well as in the treatment of fecal fistulæ. Vesico-rectal fistulæ also may be treated advantageously by exclusion of the diseased portion of intestine and the establishment of an anastomosis. In accordance with the portions of intestine to be united, the operation of entero-anastomosis is given various designations—as, for instance, ileocolostomy, colocolostomy, gastroduodenostomy, gastro-jejuno-stomy, etc.

In the establishment of intestinal anastomosis the two portions of intestine to be united are, if possible, brought out of the abdominal wound, and, after being stripped of their contents, are constricted, preferably by means of compression with the fingers. The anastomosis can be effected by means of suture or with the aid of the intestinal button. In applying sutures the two portions of intestine are brought in apposition and united in a linear direction at a point opposite the mesenteric attachment

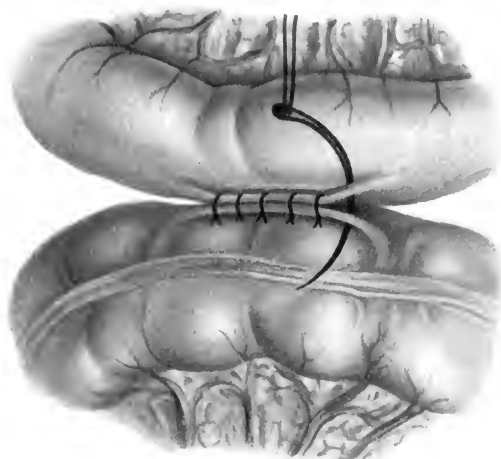


Fig. 1.

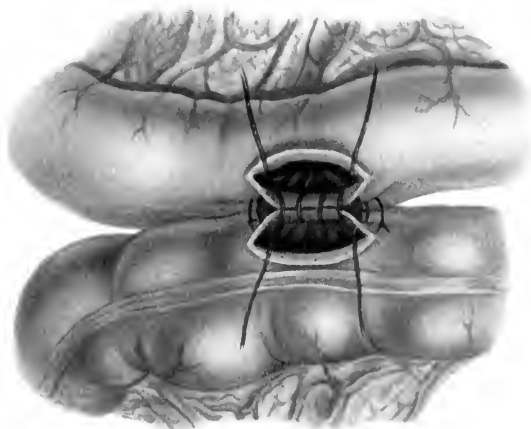
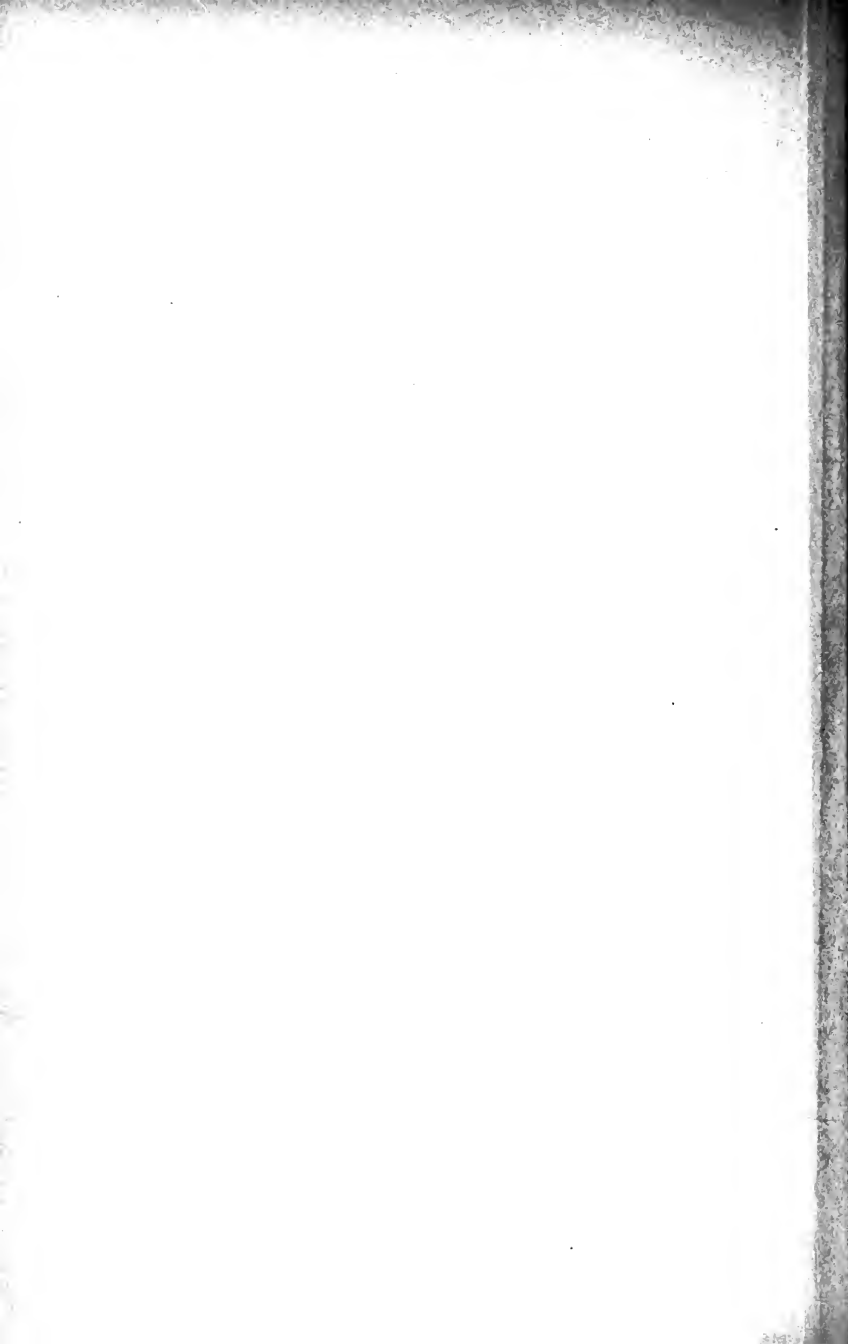


Fig. 2.



INTESTINAL ANASTOMOSIS BY MEANS OF MURPHY'S BUTTON.

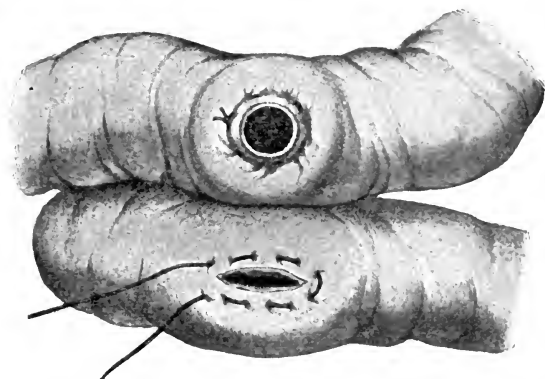


FIG. 226.—In the lower portion of the intestine the application of the purse-string suture about the opening in the intestine is exhibited. In the upper portion of the intestine one half of the button has been introduced and fixed.

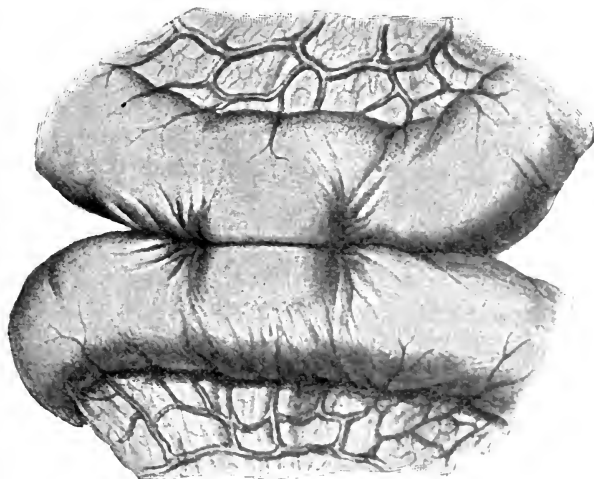


FIG. 227.—Completed intestinal anastomosis.

throughout an extent of about 5 cm. The two portions of intestine, after they have been freed of fecal matter by stripping and are appropriately clamped upon either side of the site of operation, are opened longitudinally throughout an extent of 3 or 4 cm., 0.5 cm. on either side of the serous suture. Next the opposed margins of the openings are united by suture, including the entire thickness of the wall; then the suture is applied in the same manner throughout the entire periphery of the opening made, so that closure throughout the entire circumference is effected. There yet remains the application of the second half of the serous suture, by means of which also the circle of these sutures is closed (Plate 33).

In the establishment of anastomosis with the aid of the Murphy button the two longitudinal openings are first made, and each is surrounded by a continuous suture (Fig. 226), which, after the introduction of the respective halves of the button, is tightened and tied about the neck in such a manner that the margins of the opening are drawn over the convexity of the button up to the cylindric tube. If both openings are thus armed, the halves of the button are pushed together until the tissues between the margins of the button are closely approximated (Fig. 227).

Formation of an Intestinal Fistula.—Enterostomy.—A fistulous opening into the intestine through the abdominal wall is formed when a provisional means of escape for the intestinal contents is desired.

In another group of cases the opening in the intestine is made in order to render possible the nourishment of the patient by way of the fistula. Finally, it may be necessary to permit the escape permanently of the entire intestinal contents externally through an artificial opening. In the last event the operation is described as the establishment of an artificial or preternatural anus. The establishment of an intestinal fistula through the abdominal wall is a valuable measure for evacuating fecal matter and gas in the presence of obstruction of the bowel of various kinds, in the presence of marked peritonitis and

great distention of the intestines. In cases of this character enterostomy has replaced puncture of the intestine, as formerly employed.

A short incision is made through the skin, over and in the course of Poupart's ligament. The muscles are next divided and the peritoneum incised. If distended large intestine (recognizable from its longitudinal bands and its sacculations, as well as from its epiploic appendages) comes into view, it is drawn forward, or if, on the contrary, a loop of distended small intestine presents itself in the wound, it is sutured through a small extent to the parietal peritoneum. In this procedure not only the thin serous covering of the intestine, but also the muscular layer, is grasped and the closure effected is therefore more secure. If possible, the opening into the intestine should constitute a second stage of the operation (from twenty-four to forty-eight hours later), after the peritoneal cavity has been walled off by means of adhesions. Under other conditions the intestine is penetrated with a pointed knife or the Paquelin cautery immediately after applying the serous circular suture.

Jejunostomy.—The fistula for purposes of nourishment is made as in the small intestine, as nearly central as possible in the jejunum. Originally proposed by Maydl as a substitute for gastro-enterostomy, jejunostomy is at present believed to be indicated in cases in which gastro-enterostomy is impracticable; also in the presence of extensive carcinoma of the stomach; further, in the presence of corrosion of the stomach, if the organ is so small that gastrostomy cannot be performed. Eiselsberg has applied the Witzel principle of gastrostomy to the formation of a fistula in the jejunum. The incision is made in the linea alba, between the umbilicus and the symphysis pubis. After the peritoneum has been divided the transverse colon is brought forward at the attachment of the greater omentum and reflected upward. The duodenojejunal flexure appears at the root of the mesentery. One of the uppermost loops of jejunum is brought into the wound.

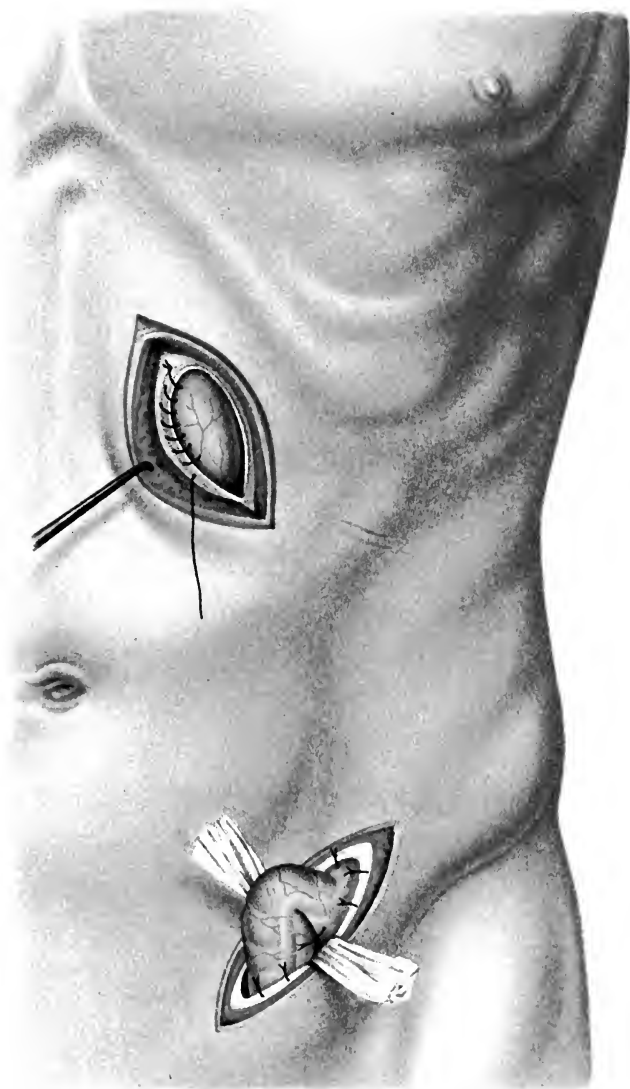
Plate 34.—Intestinal (Gastric) Fistula and Preternatural Anus.

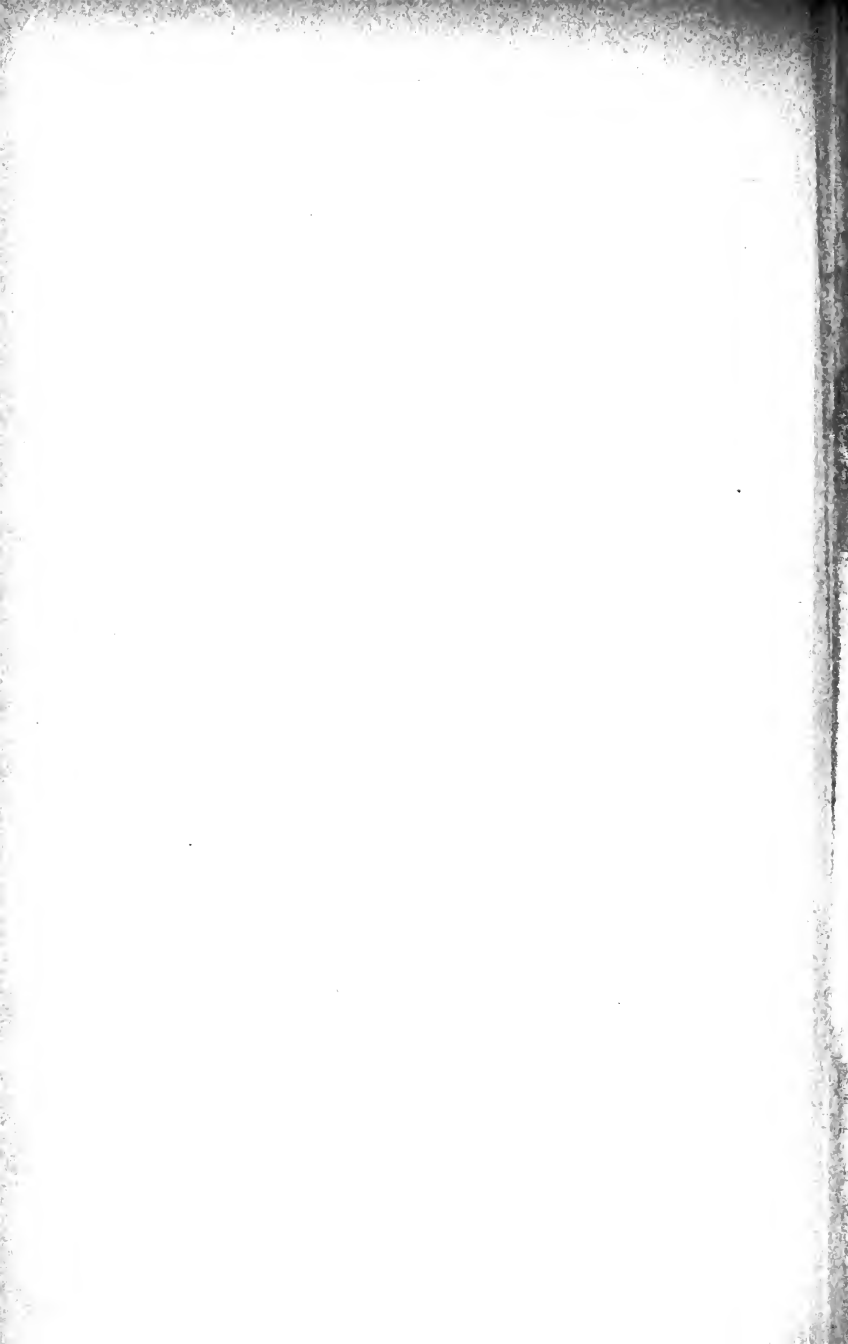
Gastrostomy.—Suturing one portion of the anterior wall of the stomach into the wound in the abdominal wall. The serous margin of the wound is united with the serous layer of the stomach by means of a continued suture.

Colostomy.—A loop of the sigmoid flexure has been drawn forward and fixed in the wound.

In the formation of the tubular fistula a drainage-tube is placed longitudinally upon the intestine opposite the mesenteric attachment. To the right and the left of the tube two parallel longitudinal folds are formed by including the serosa and the muscularis in sutures, and these are united by tying the sutures over the tube. At the lower extremity, between the sutures, the intestine is opened so far as is necessary for the introduction of the tube, and the intestinal wall is sutured over the introduced tube. The entire loop must remain suspended in the wound by means of peritoneal sutures, after which the overlying muscle and skin can be sutured. The outer extremity of the rubber tube is brought out of the wound. Nourishment is introduced through the tube. As the suture effects perfect closure, bile and pancreatic secretion are not lost to the body.

Preternatural Anus.—The formation of a preternatural anus becomes necessary when it is desired to furnish a constant channel of discharge for the intestinal contents through a fistula. The artificial anus is most commonly formed in the descending colon or the sigmoid flexure (*colostomy*) in the presence of a neoplasm or of cicatricial narrowing. The descending colon is exposed through the peritoneal cavity. The cutaneous incision is made in the left hypogastric region, three or four fingers' breadth above and in the direction of Poupart's ligament. After the peritoneal cavity has been opened a loop of the sigmoid flexure, recognizable from its epiploic appendages, is brought out of the wound. At about the middle of the loop, close to the intestinal attachment of the mesentery,





a strip of sterilized gauze is passed through a slit in the mesentery, so that the loop of intestine in a measure rides upon the gauze. To prevent the falling back of the bowel the serous layer of the abdominal wound may be united by several sutures with the serous layer of the intestinal loop (Plate 34). At a second sitting the loop of colon is divided transversely upon its convexity by means of the Paquelin cautery, at a point opposite its mesenteric attachment. This incision is progressively enlarged in the course of a few days, until it reaches the mesenteric attachment, so that finally both portions of intestinal lumen lie side by side in the wound.

The operation can also be completed at a single sitting, the loop being brought forward, divided between two ligatures, and both stumps fixed in the wound side by side, after which the ligatures are first released. If colostomy is to be combined with complete exclusion of the rectum, which, however, is without essential significance, the same course of procedure is followed, the peripheral extremity of the intestine, however, being closed blind and dropped back, while the central stump is brought out of and fixed in the wound.

Resection of the Bowel.—*Enterectomy.*—By this designation is understood excision of a portion of the intestinal tract in its continuity. The related mesentery either is removed or remains in place. After the resection has been effected, the continuity of the bowel can be restored by uniting the stumps, or these may be brought out of the abdominal wound and a preternatural anus established. Resection of the bowel is undertaken :

- (1) In the presence of injuries of the intestine ;
- (2) In the presence of gangrene of the bowel ;
- (3) In the presence of neoplasms ;
- (4) In the presence of stenosis of the bowel ;
- (5) For the correction of intestinal fistulæ.

The portion of intestine intended for resection must be detached from its surroundings, so that it can be brought out of the abdominal wound. The loops of intestine

are stripped of their fecal contents and clamped in two places by means of suitable instruments (Figs. 228-231), or pressure with the fingers or strips of sterilized gauze. The division of the bowel is effected with scissors between the clamped parts. According to the suggestion of Kocher, the plane of division should be so made that a greater portion of bowel is removed from the convexity than from the mesenteric attachment, as by this means the circular vessels of the bowel are less exposed to injury. The mesentery is ligated in successive portions and divided transversely at its attachment to the bowel, or excised in the form of a wedge whose base is formed by the resected bowel and united in a linear direction. In the first event the free mesentery is folded longitudinally and sutured after resection has been completed. After the mucous membrane projecting from the divided surfaces has been dried with sterile gauze, the disposition of the lumen of the two portions of bowel may be proceeded with (see *Intestinal Suture*, p. 302).

Recently, in place of circular suture of the intestine, anastomosis with lateral apposition is often established after resection. To this end blind closure of the stumps is effected (p. 305), and these are brought into communication with each other by means of lateral longitudinal openings. It is advisable to bring the blind sacs in such relation to each other that the extremity of the central stump is directed downward, and that of the peripheral stump in the opposite direction. The method has the great advantage that inequality in the lumen of the portions of bowel to be united in no way interferes with the performance of the operation.

Exclusion of the intestine (Salzer) is an operation comparable to resection, the bowel being divided transversely through healthy tissue above and below the diseased portion, as in the performance of resection, after which continuity is restored by circular suture or lateral apposition and anastomosis. The excluded portion of intestine, however, is not removed, but remains within the body,

INTESTINAL CLAMPS.

Fig. 228.—Billroth's
clamps.

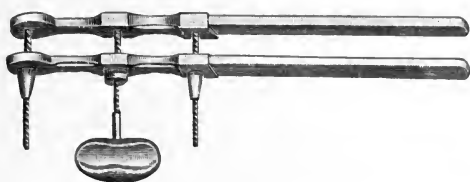


Fig. 229.—Hahn's
clamps.

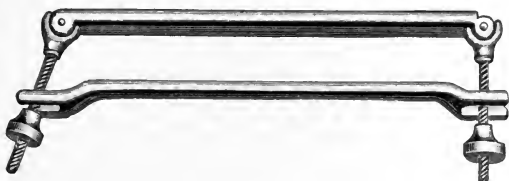


Fig. 230.—Gussenbauer's clamps.

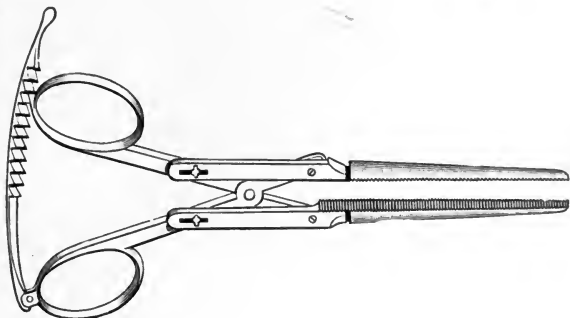
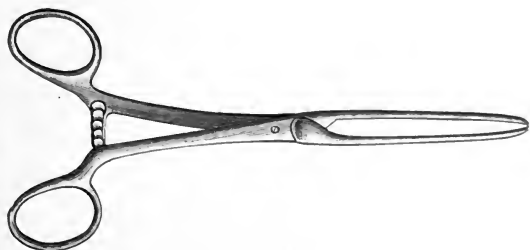


Fig. 231.—French intesti-
nal clamps with springing
branches.



while one extremity or both extremities are sutured in the skin. The operation is indicated in the presence of stenosis of the bowel, when radical removal of the diseased tissue either appears impossible (inoperable tumors) or is not considered necessary (chronic inflammatory processes), but when it is desirable that the diseased portion of intestine should be completely removed from contact with the intestinal contents.

Amputation of the Vermiform Appendix.—For the removal of the vermiform appendix in a free interval, after the inflammatory process has subsided, the cutaneous incision is made in the direction of the fibers of the external oblique muscle. According to the method of Beck, the cutaneous incision begins three fingers' breadth above the symphysis pubis, passes in the direction of the fibers of the external oblique, and ends three fingers' breadth below the anterior extremity of the eleventh rib. The muscles are divided and the peritoneum is opened. The free appendix is grasped with the thumb and index-finger and brought out of the wound. In some cases the appendix must first be freed from adhesions. The mesentery of the appendix is grasped in sections, ligated, and divided beyond the ligatures. If the vermiform appendix is freed in this manner, the tube is ligated with a silk thread, close to its point of origin from the cecum, and severed with a stroke of the scissors. The mucous membrane of the stump of the appendix visible on the amputation surface is excised by means of forceps and scissors, when the stump is closed carefully with several Lembert sutures.¹

Removal of the inflamed appendix is effected in accordance with the same rules. After careful separation of the adhesions of the cecum to neighboring structures the seat

¹ The incision employed by McBurney is very useful. The incision is perpendicular to a line drawn from the anterior superior iliac spine to the umbilicus, and crosses this line two inches to the inner side of the spine. The muscles are separated by blunt dissection. The fact that muscle-fibers are not cut is a great safeguard against hernia, because the muscles do not degenerate.—ED.

of the disease is determined. If the purulent focus has been rendered accessible, the vermiform appendix is freed from its surroundings and amputated according to the rules just laid down. The wound cavity is drained.

If a purulent accumulation of considerable size is demonstrable through the abdominal walls, the incision is made in the direction previously named over the most marked convexity of the tumor. After the abdominal walls are divided down to the peritoneum, an attempt is made to gain access to the purulent focus by careful puncture with a grooved director. If this has been successful, the exploratory opening is enlarged by blunt dissection and the pus is evacuated. With a careful regard for the adhesions to the wall of the cavity, efforts are made to reach the appendix, which is freed and amputated. In the presence of gangrenous destruction of the appendix, there can, of course, be no question of its systematic removal. The remains of the organ are removed, and the wound cavity is tamponed. If the abscess is not sacculated, and if general peritonitis is present, the pus is evacuated after the abdominal cavity has been opened, and the peritoneal cavity is cleansed and drained.

Operations on the Stomach.—Establishment of a **Gastric Fistula.**—**Gastrostomy.**—A gastric fistula is established in order to introduce nourishment into the stomach when the esophagus is occluded by carcinoma or cicatricial stenosis. In the latter event the fistula should, besides, render instrumental dilatation of the esophagus possible or easier.

The stomach is reached by division of the abdominal wall in the epigastric region, either in the middle line or to the left.

The stomach may be readily recognized by the characteristic radiation of the vessels from the greater and lesser curvatures. Further, its walls are thicker than those of the small intestine, and the organ is to be distinguished from the large intestine by the absence of sacculation. The stomach is most readily reached by grasping a por-

tion of the great omentum and following it from the periphery toward the greater curvature.

The original and most primitive method of performing gastrostomy is as follows: A cutaneous incision 6 or 8 cm. long, parallel with and some 2 or 3 cm. distant from the left costal margin, is made. The upper extremity of the incision is about a thumb's breadth to the left of the apex of the ensiform cartilage (Fig. 221, *b*). The muscles of the abdominal wall are separated by blunt dissection, and the peritoneum is opened in the direction of the cutaneous incision. The stomach is drawn out of the wound, so that its summit reaches the level of the skin. A continued suture attaches the parietal peritoneum of the wound in a circular manner to the base of the withdrawn portion of stomach. The stomach is advantageously opened twenty-four hours later by means of the Paquelin cautery. Should there be danger in delay, the stomach may be opened immediately, a small incision being made in the viscus in correspondence with the cutaneous wound. The serous coat of the stomach, if united with the skin, will quickly adhere.

The fistula established in this way has the disadvantage of incontinence. The nutritive fluids injected escape when the patient is in the erect posture, and the surrounding skin suffers from contact with the acrid gastric juice. Nevertheless, the fistula will be established in this manner when it is intended to undertake dilatation of the esophagus through the opening in the stomach. Continent gastric fistulæ can be obtained if the stomach is not made to empty directly outward by the shortest route, but by the formation of a rather long fistulous canal. The most important methods of this kind are the following:

Gastrostomy by the Method of Hacker-Witzel.—A vertical incision is made through the skin over the middle of the left abdominal rectus muscle, passing downward from the costal arch for a distance of 7 or 8 cm. The fibers of the muscle are separated by blunt dissection, the posterior sheath of the rectus and the peritoneum are divided,

GASTROSTOMY BY THE METHOD OF HACKER-WITZEL.

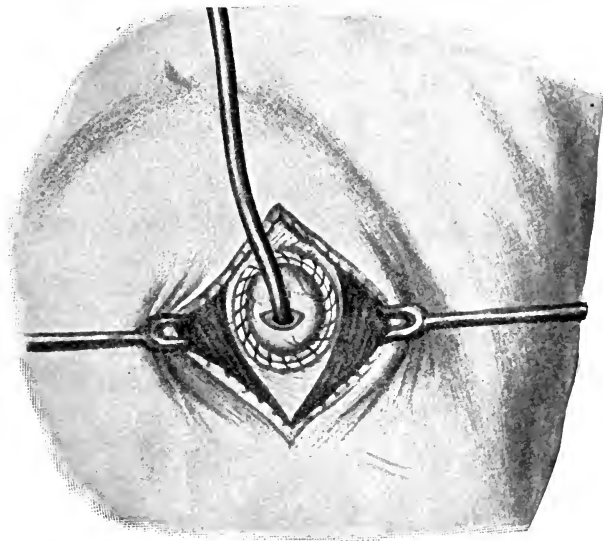


FIG. 232.—The stomach is drawn forward and sutured in the peritoneal wound. By means of an incision near the lower pole a tube is introduced into the cavity of the stomach. The muscles visible to the right and the left are the halves of the abdominal rectus muscle divided longitudinally.

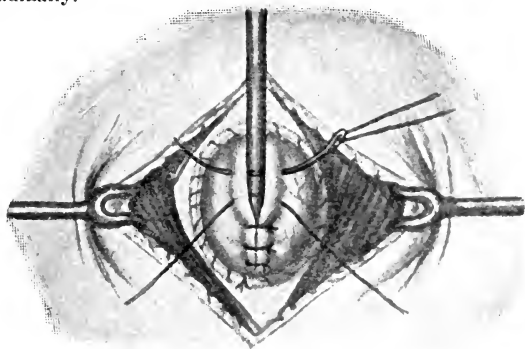


FIG. 233.—Formation of a tubular fistula. The extremity of the introduced rubber tube is applied to the stomach and is covered over with serosomuscular sutures.

and a portion of the stomach is withdrawn and sutured, at the base of the protruding cone, to the parietal peritoneum. An opening in the stomach large enough to permit the introduction of a rubber tube about 5 or 6 mm. in diameter is made (Fig. 232). The extremity of the tube dips into the cavity of the stomach, and the tube is applied to the stomach in the direction of the cutaneous incision, and is secured by means of sutures between two folds, consisting of the serous and muscular layers (Fig. 233). This canal can be made of any desired length by sutures. Witzel recommends a length of from 4 to 8 cm. Finally, the stomach is attached to the skin by means of a few sutures at the upper extremity of the canal of Witzel, and the remainder of the wound is drained downward and closed by suture.

The operation can be performed in two sittings or in one. In the first event the withdrawn portion of stomach is surrounded by the peritoneum of the wound in the abdominal wall, and the fistula is established twenty-four hours later. If it be desired to complete the operation at a single sitting, it is a matter of indifference whether the canal is formed at first and the withdrawn stomach is suspended in the wound by means of serous sutures at the close, or whether before opening the stomach the abdominal cavity is closed off in the manner described. The escape of gastric contents can be prevented advantageously by the application of two intestinal clamps by means of which the field of operation upon the stomach can be completely limited.

The method of Marwedel and that of Schnitzler are improvements upon the method of Witzel. Marwedel makes in the stomach, sutured in the abdominal wound, an incision 4 or 5 cm. long in the direction of the channel to be formed. This passes only through the serosa and the muscularis, leaving intact the mucous membrane of the stomach. At the lower extremity of the incision the mucous membrane is opened by a small transverse incision, through which a rubber tube is introduced, and

attached to the mucous membrane by a catgut suture. The entire wound in the stomach is united over the tube, and in this way a passage similar to Witzel's canal is made in the submucosa.

Schnitzler establishes a submucous fistulous canal in a simpler manner. The stomach, drawn forward, is opened by means of a short incision. A tube is introduced into the stomach, and a small incision is made through the serosa and the muscularis, down to the mucous membrane, 4 or 5 cm. above the first incision. Through the opening thus made a forceps is passed in the submucous layer down to the tube, which is grasped at its outer extremity and brought out through the upper slit. Both openings are closed by means of Lembert sutures. The portion of the stomach containing the canal is surrounded by parietal peritoneum, and the stomach is attached to the upper extremity of the cutaneous wound by means of a number of sutures.

The canal of the gastric fistula passes, according to the method of Kader, not in an oblique, but in a vertical, direction through the wall of the stomach. A tube is introduced into the stomach through a small opening, and while it is held perpendicularly to the wall, it is enclosed within folds of the stomach at its base and covered in with sutures in tiers.

Frank makes the cutaneous incision parallel with the costal arch, and after dividing the peritoneum withdraws the stomach in the form of a cone for a distance of 3 or 4 cm. and which, armed with a thread passed through its apex, is sutured at its base to the parietal peritoneum. A second incision, 1.5 cm. long, is made through the skin along the costal arch, two fingers' breadth above the first. Between the two incisions the skin is freed and the teat of stomach is passed beneath the bridge of skin and fixed into the upper wound and incised at its summit. The first incision is then closed by suture. The fistulous opening lies above the level of the stomach and can be readily compressed by the overlying loop-like bridge of skin.

Gastro-enterostomy.—The establishment of a communication between the stomach and the small intestine is undertaken in the presence of stenotic carcinoma of the pylorus, which is not amenable to radical operation, and also in the presence of cicatricial stenosis of the pylorus, in order that the gastric contents may empty directly into the small intestine, with avoidance of the constricted passage. In the former event the operation is a palliative procedure, while in the latter it may induce permanent recovery. The anastomosis is established between the stomach and a loop of jejunum, and the fistula may be made in the anterior or the posterior wall of the stomach. In the first event (*anterior gastro-enterostomy*, Wölfler's method) the loop of small intestine is brought over the transverse colon to the stomach; therefore the operation is designated also *antecolic gastro-enterostomy*.

Hacker makes the small intestine communicate with the posterior wall of the stomach (*posterior gastro-enterostomy*). The method is intended to permit of a natural situation of the small intestine after the establishment of the fistula, and, besides, to render impossible compression of the transverse colon by the small intestine. The inconveniences that result after the performance of *anterior gastro-enterostomy* from the unnatural position of the small intestine can be avoided if a loop is selected for anastomosis that is correspondingly remote from the duodenojejunal flexure. If both walls of the stomach are free, the decision as to the establishment of the anastomosis on the anterior or the posterior wall may be left to the preference of the surgeon. If the anterior wall of the stomach is infiltrated, it will be necessary to perform Hacker's operation; while under the opposite conditions, if the posterior wall is involved or is not accessible on account of the fixation of the stomach, *anterior gastro-enterostomy* will be necessary.

Anterior Gastro-enterostomy.—The cutaneous incision is made in the linea alba, between the ensiform cartilage and the umbilicus, and the abdominal cavity is opened.

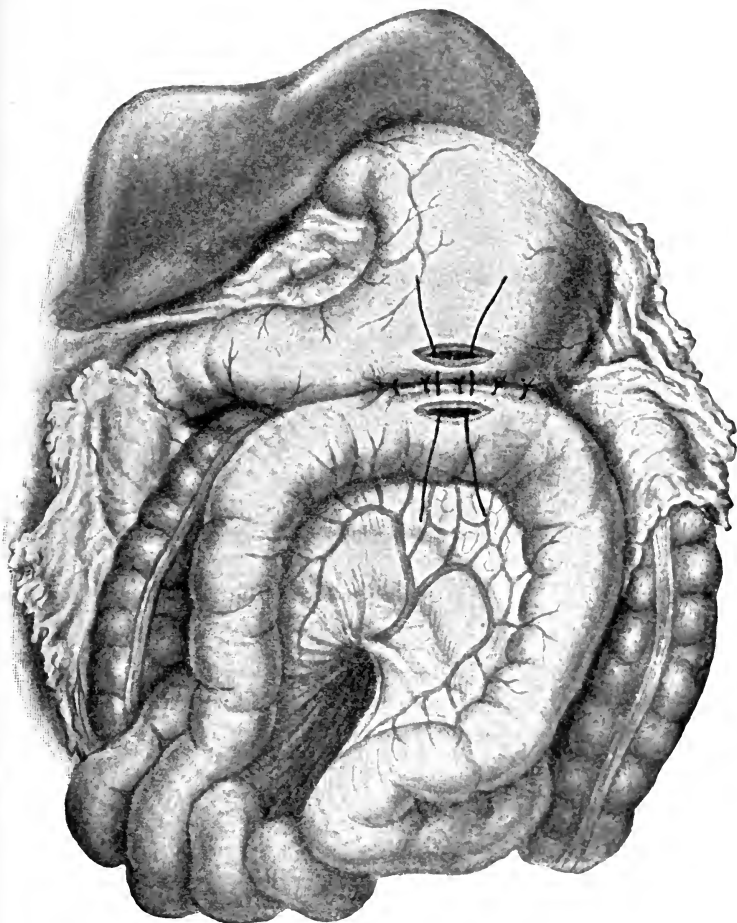


FIG. 234.—Anterior gastro-enterostomy. A general view of the topographic relations in the performance of anterior gastro-enterostomy. A loop of jejunum has been thrown over the transverse colon and attached to the anterior wall of the stomach. The descending portion of the loop agrees in its direction with the natural continuation of the stomach.

The condition of the stomach is first to be determined, and the points of anastomosis on this organ, as well as on the small intestine, are to be decided upon. On the stomach this will be on the anterior wall, midway between the pylorus and the fundus, over the greater curvature. The point on the small intestine is from 40 to 50 cm. to the peripheral aspect of the duodenojejunal flexure. If the transverse colon, together with the great omentum, is

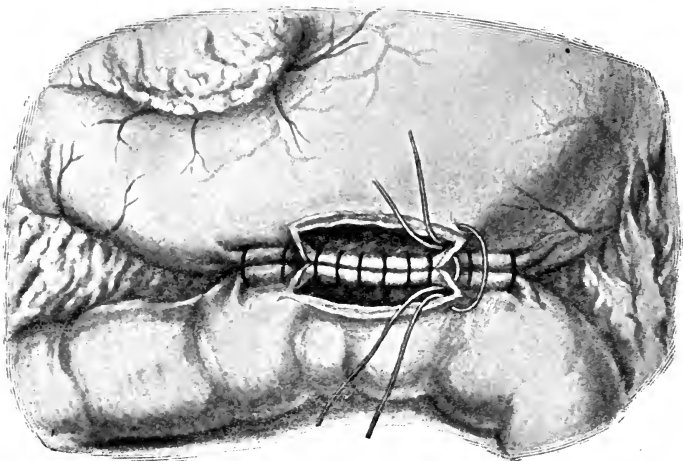


FIG. 235.—The extremities of the fixing sutures in the serous layer are still visible. The two portions of intestine are opened. At the posterior boundary the sutures, including all the layers, are applied.

drawn out of the wound and is reflected upward in such a manner that also its mesentery is put upon the stretch, the ascending portion of the duodenum and the sharp bend of the duodenojejunal flexure will become visible at the root of the mesentery, to the left of the second lumbar vertebra, so that from this point the desired situation on the jejunum can be determined with certainty. The stomach and the selected portion of small intestine remain out of the wound, while the remainder of the intestine is re-

placed. The intestine and the stomach are approximated either instrumentally or with the pressure of the fingers, and brought into approximation. A row of seromuscular sutures attaches the intestine at its convexity to the anterior wall of the stomach in a linear direction throughout the desired extent (Fig. 234).

The greater the extent throughout which the loop is attached to the stomach, the more certainly will the

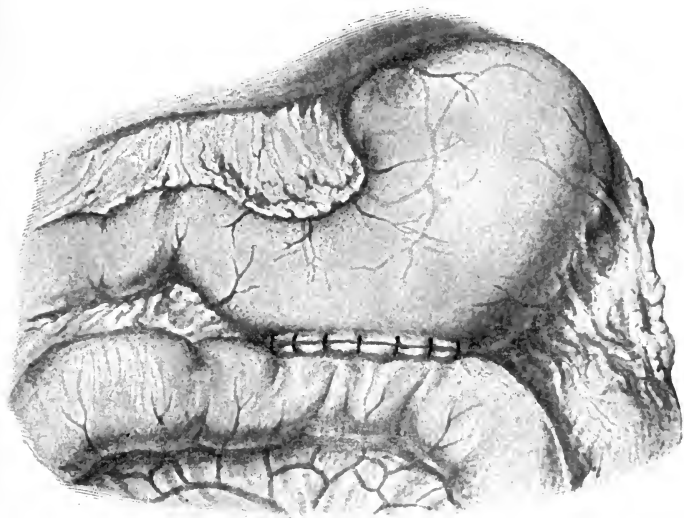


FIG. 236.—Situation after the operation has been completed.

formation of a spur, which may interfere with the functions of the fistula, be avoided. Now, the stomach and the intestine are opened at a distance of from 0.5 to 1 cm. from the sutures introduced, by means of a longitudinal incision from 4 to 6 cm. long, and the opposed margins of the openings united by suture, including the entire thickness of the wall (Fig. 235). The same suture is continued in like manner on the anterior aspect until union is effected

throughout the entire circumference. The circle of overlying seromuscular sutures also is closed, so that at every point two rows of sutures secure the anastomosis (Fig. 236). The two portions of intestine are dropped into the peritoneal cavity, and the wound in the abdominal wall is closed in tiers.

In place of suture Murphy's anastomosis button also can be advantageously employed in the performance of gastro-enterostomy. In establishing the fistula the rules laid down on page 309 should be followed.

Posterior Gastro-enterostomy.—The first half of the operation, to the exposure of the duodenojejunal flexure, is analogous to that of anterior gastro-enterostomy. After the transverse colon is reflected upward in the manner described, an incision is made into the mesocolon parallel to the direction of the vessels, and through which the posterior wall of the elevated stomach is reached. A cone of the stomach is brought out through the opening. The margins of the gaping wound in the mesocolon are attached to the stomach in such a manner that the uppermost loop of jejunum (about 15 cm. from the flexure) can readily be approximated to the exposed stomach (Fig. 237). The anastomosis is established in the manner previously described. After suturing has been completed, the transverse colon, together with the great omentum, is restored to its normal position. In making the fistula, care should be taken to have the contents of the stomach readily find their way into the terminal portion of the intestine. Should the discharge be imperfect, stasis in the supplying portion should at least be avoided. Finally the entrance of intestinal contents into the stomach should be prevented.

Wölfler has emphasized the fact that the intestine should be attached to the stomach in such a manner that the gastric contents are propelled directly into the terminal portion of intestine by peristaltic activity. Lauenstein makes the fistula in an oblique direction, from the left and above to the right and downward, so that the

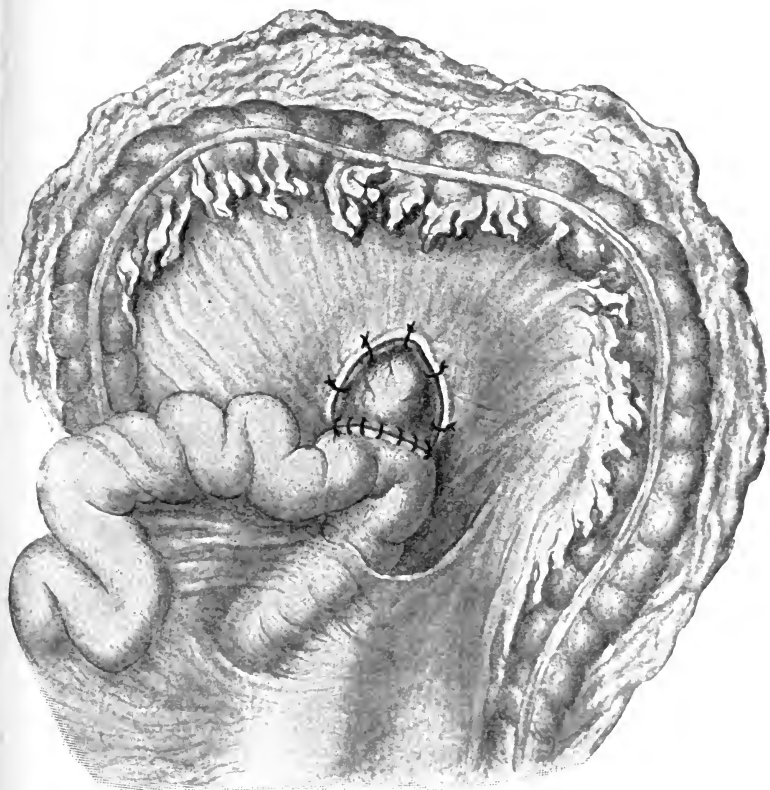


FIG. 237.—Posterior gastro-enterostomy. The transverse colon, together with the stomach, is reflected upward. The posterior wall of the stomach is visible through a longitudinal incision in the mesocolon. The loop of small intestine situated nearest the duodenojejunal flexure is attached to the stomach by serous sutures for the formation of an anastomosis.

terminal portion of intestine lies in the direction of the peristaltic activity of the stomach; the supplying loop of intestine is attached to the stomach some distance to the left and above the fistula. In any event, broad attachment of the loop to the stomach is important, inasmuch as in this way kinking and the formation of a spur in the sutured jejunum are most readily to be avoided. In order to overcome the annoyance resulting from stasis of intestinal contents in the supplying loop in the presence of defective discharge, Lauenstein has recommended following the gastro-enterostomy the establishment of an anastomosis between the supplying loop and a loop of the jejunum. For the same purpose Braun establishes an anastomosis between the two arms of the loop of jejunum sutured to the stomach.

In order to prevent regurgitation from the intestine into the stomach, Kocher attaches the loop of intestine to the stomach in such a manner that the former is placed vertically to the greater curvature. The intestine is incised transversely on its convexity, and the stomach is opened in the usual manner. The supplying loop is applied to the stomach, and the discharging portion hangs free below. The gastric contents must be discharged directly into the intestine, passing vertically downward. Wölfler attains the same end by incising the loop of small intestine, implanting the terminal limb upon the stomach, and permitting the proximal portion to enter laterally into the wall of the lower extremity. Finally, numerous attempts have been made to form a sort of valvular closure of the gastric fistula by the formation of flaps (Wölfler, Kocher, Sonnenburg, and others).

Resection of the Pylorus.—Resection of the pylorus was first performed successfully by Billroth (1881). The operation is indicated in the presence of carcinoma of the pylorus, if the new growth is movable and has not invaded surrounding structures. The cutaneous incision is made in the linea alba, between the umbilicus and the ensiform cartilage, or, according to Billroth's original

method, in the epigastrium, transversely through the abdominal recti muscles. Only after the abdomen has been opened can a decision be reached as to whether resection of the pylorus is proper or possible. The anterior aspect of the stomach is palpated, and, if necessary, also the posterior aspect through a slit made in the lesser omentum, and the mobility of the tumor is determined. The next step in the extirpation consists in isolating the pylorus. For this purpose the attachments of the greater and the lesser omentum to the stomach must be divided in so far as this is to be excised. Next, the gastrocolic ligament is doubly ligated in segments and divided between the ligatures. The gastrohepatic ligament is treated in an analogous manner. The pyloric portion of the stomach, thus rendered mobile, is brought forward and clamped through healthy tissue on each side of the tumor, after which the excision is practised with scissors. Billroth generally made the incisions into the stomach and the duodenum oblique from the left and above to the right and downward. The visible vessels in the transverse incision are ligated, and closure of the wound is proceeded with. This can be effected in several ways :

1. The margins of the wound in the stomach and the duodenum are united by circular suture (Billroth). In order to effect apposition of the lumen of the two parts, the wound in the stomach is closed from above until it is reduced to the desired size. Only then is the cut surface of the duodenum united with the lower half of the wound in the stomach. The sutures are applied in tiers according to the rules given on p. 302.

2. In place of circular union, Kocher performs gastroduodenostomy after resection of pylorus. The wound in the stomach is closed throughout its entire extent by a continued suture in two tiers; the first includes all the layers, while the second is a Lembert suture that lies over the inverted first row. The duodenal stump is made by Kocher to enter an opening made in the posterior wall of the stomach. After extensive resection of the pylorus,

when direct union is not possible on account of the great separation of the stomach from the duodenum, Billroth has effected blind closure of both stumps, and then performed gastro-enterostomy.

Exclusion of the Pylorus.—In the presence of inoperable tumors of the stomach Eiselsberg has combined gastro-enterostomy with exclusion of the pylorus, in order, in the presence of pain or of a tendency to profuse hemorrhage, to remove the ulcerated surface completely from contact with the gastric contents. First, the stomach is incised in a vertical direction between intestinal clamps to the central aspect of the tumor, after the attachments of the greater and the lesser omentum in this situation are freed, when, after hemorrhage has been controlled, each of the wound surfaces is closed separately by a double row of sutures. To the cardiac portion of the stomach one of the upper coils of jejunum is attached by lateral anastomosis, so that the portion of the stomach into which the esophagus and the intestine enter are completely isolated from the pyloric portion.

Operations upon the Rectum and the Anus.—

Amputation and Resection of the Rectum.—Operations for the removal of tumors of the rectum will vary with the seat and the extent of the morbid process. Circumscribed or pedunculated tumors are surrounded by incisions at their base, and severed through healthy tissue, the wound created being closed by suture. It is difficult in the treatment of cases of this kind to expose sufficiently the field of operation. For more deeply seated tumors, in the region of the anus, it is sufficient to distend this portion of the bowel by means of retractors or suitable specula. Tumors seated high up require as a preliminary operation linear division of the sphincter, which is practised on the anterior and posterior aspects along the line of the raphe, with marked retraction of the margins of the wound, and renders accessible to the knife the portions of the rectal mucous membrane above the sphincter. The anterior wall of the rectum can be reached with the aid of a pre-

rectal incision by separation of the rectum from the urethra (see Prostatectomy). By this means the entire thickness of a circumscribed portion of the wall of the rectum can be resected and the defect be closed by suture. If the neoplasm involve the entire periphery of the lowest portion of the rectum a circular incision is made around the anus and the lower extremity of the rectum is freed from its surroundings. The rectum is then divided transversely upon the proximal side of the neoplasm. The wound is so adjusted that the stump of the rectum, brought to the level of the surface, is fixed to the skin by sutures passing through all the layers of the wall of the bowel. This method of amputation has a limited field of application. If the upper border of the tumor can be reached with the palpating finger, its removal by the method detailed can be technically carried out; but isolation of the rectum in its upper portions and access to the sigmoid flexure are quite impossible by this mode of procedure. The cutaneous wound allows of limited access, so that certainty in operation, especially control of hemorrhage in the higher portions of the wound, encounters irremovable obstacles.

Resection of the rectum, with union of the stumps of the intestine, by the method described, is difficult even if access is afforded by anterior and posterior incisions through the raphe, also when the tumor is deeply seated, and entirely impossible if this be situated in the upper portion of the rectum.

The limits of operability of tumors of the rectum were enlarged materially with attempts, on Kraske's suggestion, to expose the rectum sufficiently and also in its higher portion through the sacral route. It is possible by this mode of procedure to isolate the rectum even to its intraperitoneal portion and to practise resections of this portion of the bowel in its continuity, with an adequate field of operation. The rectum can be reached from the posterior aspect after division of the sacrotuberous and sacrospinous ligaments through the wide interval on either

side between the margin of the sacrum and the tuberosity of the ischium. The accessibility is increased by removal of a portion of the margin of the sacrum with a chisel.

Mode of Effecting Sacral Exposure of the Rectum (Hochenegg).—The patient occupies the left lateral decubitus with the lower extremities flexed at the hips and the knees and the operator standing back of the patient. The cutaneous incision begins at the middle of the left sacro-iliac symphysis and passes over the middle line in an arc whose convexity is directed toward the right and terminates below the apex of the coccyx; or, if the anal portion also is to be removed, it surrounds the anus elliptically (Fig. 238). The incision is deepened down to the bone. The soft parts are retained in connection with the skin and are dissected from the bone so that the left half of the sacrum and the coccyx are exposed in the wound. After enucleation of the coccyx access to the rectum will be already relatively free and it becomes considerably greater after division of the attachments of the sacrotuberous and sacrospinous ligaments in the wound. The extensive field of operation thus exposed permits of careful scrutiny with regard to the extent and limits of the tumor, and even of the higher portions of the rectum, not accessible through the usual modes of procedure. Further extension of the field of operation can be effected by chiseling the sacrum. The lower extremity of the left half of the sacrum is removed at the level of the third sacral orifice, or the sacrum is divided transversely at this level.

After exposure of the rectum the second step of the operation—that is, isolation of the tumor beyond its limits—is undertaken. The rectum is separated from its surroundings by blunt dissection, and the visible vessels are ligated in the wound. If high amputation of the rectum is to be performed, the stump of the bowel is brought down and fastened to the skin in the upper angle of the wound (sacral preternatural anus). This procedure is indicated when the anal portion is involved in the new-

FIG. 238.—Position and incision for sacral extirpation of the rectum by the method of Hocheneggs.

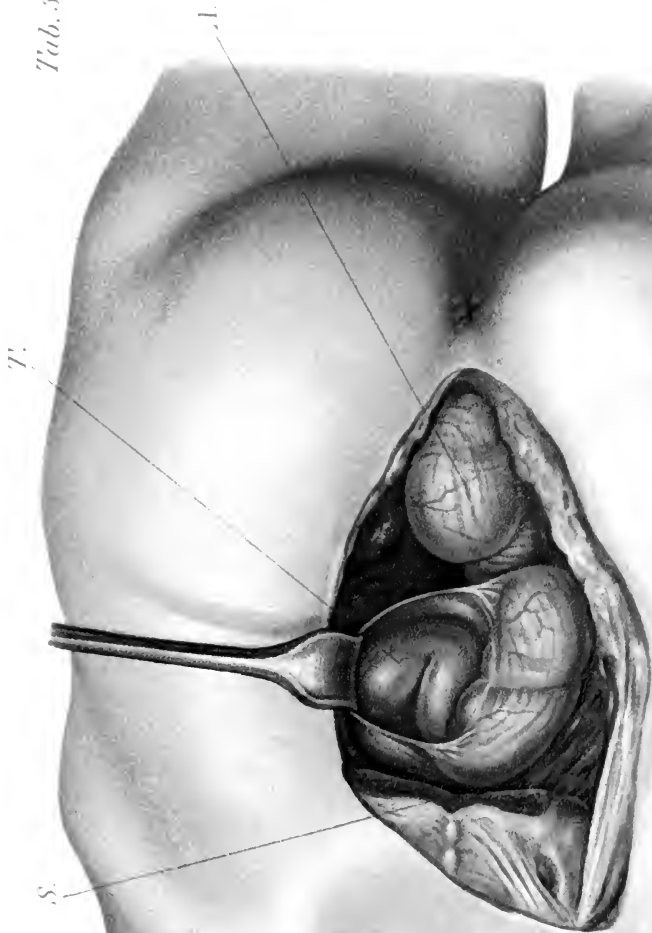


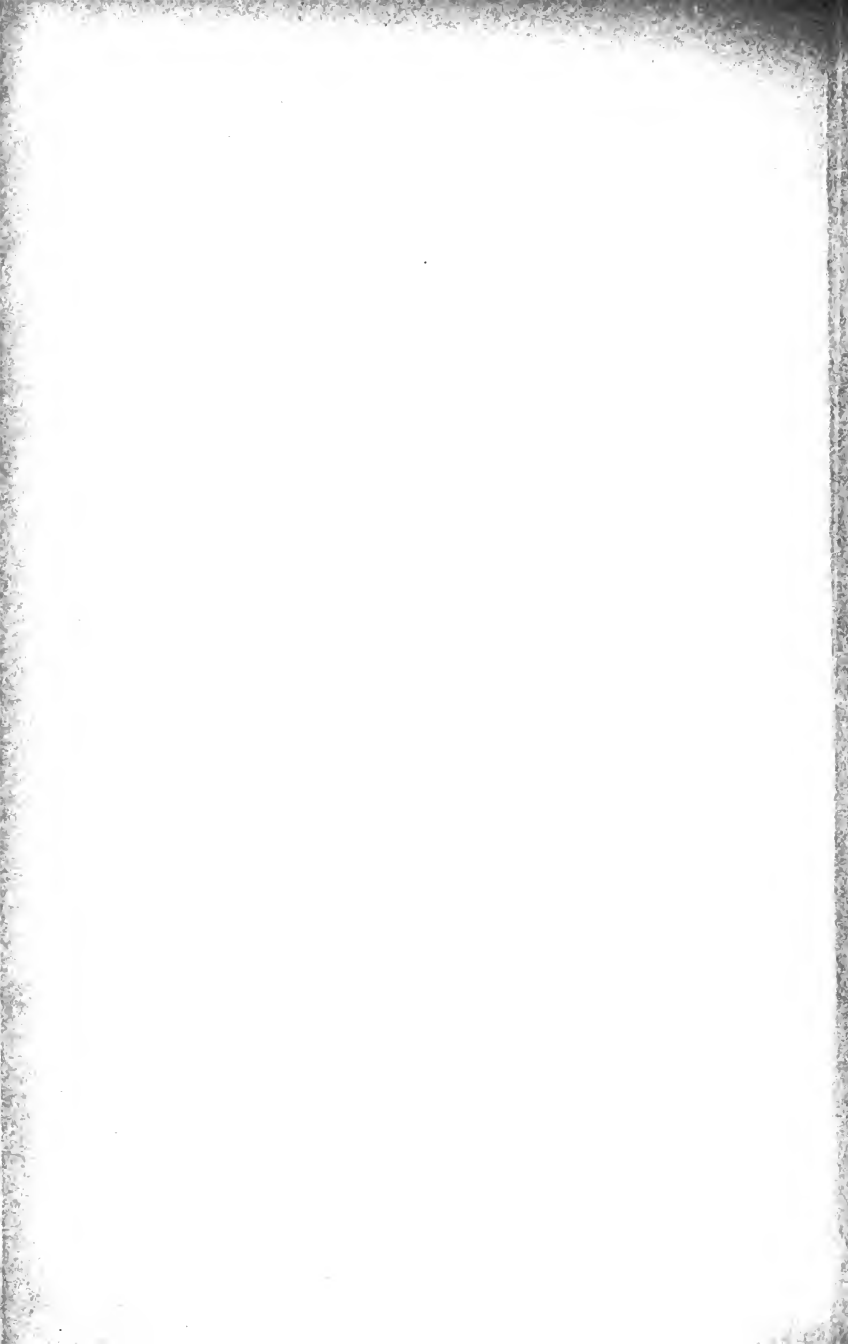
Plate 35.—Exposure of the Rectum by the Sacral Route.

The sacrum (*S*) is chiseled through transversely. The ampulla (*A*) and the upper portions of the rectum are visible. The peritoneum is divided through its attachment to the rectum, so that the contiguous intraperitoneal portions of the sigmoid flexure (*T*) are rendered visible.

growth and must be removed in connection therewith. If, on the other hand, the anal portion is healthy, the tumor being seated in the middle portion of the rectum, the bowel on either side of the morbid process is isolated by blunt dissection into healthy tissue, ligated, and the diseased part is removed by resection. The two stumps of the intestine are united either primarily throughout their entire extent, or sutured only partially, so that a provisional artificial anus is formed. This forms a mural fistula, which may either close spontaneously or be closed after a time by a plastic operation. In introducing the sutures, both stumps must be approximated without any tension. Another method (Hochenegg) consists in passing the central stump through the anal portion freed of its mucous membrane, or reflected outward, and fixing it in this invaginated position to the anus by sutures. In the isolation of tumors seated high up it is generally necessary to open the peritoneum of the vesicorectal cul-de-sac (Plate 35). The proximal stump of the rectum is brought into the wound for the formation of an artificial anus or for suture, and the anterior lip of the peritoneal wound is united at a suitable level with the serous layer of the intestine, so that the abdominal cavity is walled off from the wound. After the introduction of circular intestinal sutures a large drainage-tube is introduced through the anus into the rectum beyond the line of suture.

Resection of the sacrum has been practised by several surgeons (Heineke, Gussenbauer, and others) by osteoplastic means. Through a posterior median incision (Heineke) from the left margin of the sacrum obliquely upward the sacrum is divided transversely at the level of the fourth sacral foramen. Gussenbauer saws through





the upper portion of the sacrum in a transverse direction and also longitudinally. The two flaps of soft parts and bone are reflected upward, and, after the operation has been completed, are reunited.

Operations for Rectal Fistula.—Rectal fistula can be made to heal by division of the fistulous tract and the conversion of the tubular ulcer into an open wound. In the operation for complete fistula a slender probe is introduced through the external fistulous opening, while the index-finger of the left hand is applied to the internal opening, which often is appreciable as a loss of substance. The probe is thus passed through the tract and enters the lumen of the bowel. A grooved director may be readily passed through the fistula by the side of the probe into the rectum and its extremity brought out through the anus. The soft parts covering the fistula thus come to lie upon the director, upon which they are divided with the knife. By the introduction of retractors after division of the tissues the character of the lining of the fistulous tract can be rendered visible. As a rule, the wound is permitted to heal by granulation, although after extirpation of the entire fistulous passage the wound can be closed completely by suture.

Incomplete fistulæ must be converted into complete fistulæ before being divided. In the presence of an incomplete external fistula the grooved director is introduced and pushed into the rectum through the deepest portion of the fistula. Division of the fistula thus made complete is effected in the manner described. In the presence of an incomplete internal fistula, with its opening upon the mucous membrane of the rectum, the probe is introduced from the rectum toward the skin. When the head of the probe is felt beneath the skin, an incision is made down upon it and the complete fistula thus established is divided in the manner described. In the presence of extensive fistulous formations it becomes necessary to follow the manifold ramifying passages often present and to open them adequately.

Operation for Hemorrhoids.—Dilatations of the external hemorrhoidal veins do not require operative treatment. Operation is indicated only in those cases of dilatation of the internal hemorrhoidal veins, with consecutive changes in the mucous membrane, in which prolapse of the mucous membrane of the rectum has taken place, which makes itself apparent either only upon increased abdominal pressure or habitually as a result of this influence. The prolapsed masses of mucous membrane are either destroyed with the actual cautery, or subjected to atrophy through the action of the ligature, or excised by a cutting operation.

Cauterization.—The patient occupies the position as in the operation for stone, or the lateral decubitus. By means of digital dilatation of the anus the hemorrhoidal masses are exposed to view. They are grasped in segments with a clamp-forceps and their base is surrounded by Langenbeck's flat forceps. The tumor lying upon the broad ivory plate of the forceps is totally destroyed with the tip of the Paquelin cautery, after which the forceps is carefully removed. In the same manner the swellings throughout the entire circumference of the rectum are destroyed.

Elastic Ligature.—The patient occupies the lateral decubitus. By means of a clamp polyp-forceps the extruded mass of mucous membrane is grasped at its base and brought forward. The elastic ligature is passed around the neck of the nodule behind the forceps and tightened and fixed by means of a silk thread. In this way the whole series of folds is included in three or four parts and ligated. The necrotic nodules are thrown off in the course of a week.

Excision may be practised upon each nodule individually, or a circular incision is made through the skin around the anus and also through the mucous membrane of the rectum above the level of the nodules. The cylinder of mucous membrane, together with the dilated veins, is dissected free from the sphincter and the margin of

the mucous membrane is united by suture with the skin at the anus.

Operation for Atresia of the Anus.—The incision is made in the perineal raphe from the apex of the coccyx to the root of the scrotum (posterior commissure). The operator advances into the depth layer by layer, always keeping strictly in the middle line. As a rule, the bluish-colored cul-de-sac of the rectum is soon reached, and it is incised in the direction of the cutaneous incision. After the meconium has been discharged the bowel is united throughout its entire periphery to the skin by sutures passing through the entire thickness of the wall of the intestine. If the cul-de-sac terminate high up in the rectum, an effort should be made to reach it by the sacral route. In the presence of atresia ani vesicalis, vaginalis, an attempt is made to dissect free the lower end of the intestine by means of the same incision. The abnormal communication is divided with scissors, and the rectum is fixed in the wound by sutures in the manner described. The defect in the vagina or the bladder made by the separation of the rectum must have been closed previously by suture.

Operations upon the Biliary Apparatus.—Besides abscesses and cysts of the liver, for whose operative treatment no special rules can be laid down, attacks upon the biliary apparatus are directed especially toward the removal of calculi and their sequelæ. The surgery of the biliary apparatus, the youngest department of abdominal surgery, has been systematically practised only since the beginning of the eighties. The cutaneous incisions through which the transverse fissure of the liver is reached are varied. At times access is gained through the linea alba. At other times a longitudinal incision is made along the outer border of the rectus abdominis muscle. Czerny makes an angular incision, whose vertical arm passes along the linea alba, and is joined below the umbilicus by a horizontal incision passing toward the right and outward. In all cases after opening the peri-

toneal cavity the right lobe of the liver is reflected upward so that its under surface is exposed to view, together with the gall-bladder and the transverse fissure. Between the last and the lesser curvature of the stomach there extends a duplication of the peritoneum (the lesser omentum) in whose right free extremity pass the large biliary ducts, the portal vein, and the hepatic artery in the order given.

Cholecystotomy and Cholecystostomy.—The gall-bladder is opened by incision (*cholecystotomy*) for the removal of gall-stones, and the evacuation of empyema or dropsy of the gall-bladder. Incision of the gall-bladder may be made in one stage, or, after suture of a portion of the viscus into the abdominal wound, in two stages. In operating at a single sitting, after removal of calculi present, the wound in the gall-bladder may be united by suture and the abdominal wound be closed (*ideal cholecystotomy, cholecystendysis*), or the sutured gall-bladder may be suspended at the level of the wound. If primary suture be not undertaken, a fistula of the gall-bladder through the abdominal wall may be established according to the rules that govern intestinal operations (*cholecystotomy*). With regard to the performance of cholecystotomy it need only be said that after making the cutaneous incision and opening the peritoneum the gall-bladder should be brought as fully as possible to the level of the wound, where it is attached and held in position with sutures. After puncture of the viscus it is incised and under guidance of the finger calculi present are removed with the aid of forceps or a spoon, attention being given to the possible presence also of stones in the cystic duct. The wound in the gall-bladder is united with two tiers of sutures in the same way as wounds in the intestines. The first row of sutures includes the entire thickness of the gall-bladder and approximates opposed wound-surfaces. The second row consists of Lembert's serous sutures, and is intended to insure perfect closure of the wound by the approximation of broad surfaces of peritoneum. In performing cholecystotomy in two stages, a portion of the gall-bladder brought into the

wound is attached to the parietal peritoneum, as in the operation of gastrostomy, and the exposed portion is opened with the Paquelin cautery after the lapse of several days.¹

Cholecystectomy.—Extirpation of the gall-bladder (*cholecystectomy*) is indicated in the presence of neoplasms of this viscus, as well as of gall-stones attended with inflammatory processes in the walls of the gall-bladder. The typical procedure consists, after transverse division of the cystic duct between two ligatures, in separating the gall-bladder by blunt dissection from its attachments to the liver, which, under favorable conditions, can readily be effected after division of its serous covering.

Choledochotomy, or opening of the choledoch duct by incision, may be necessary for the removal of impacted calculi. The liver is raised up and the index-finger of the left hand is introduced into the foramen of Winslow, and in this way the generally thick-walled and dilated choledoch duct is distended. An incision is made upon the stone, whose situation is determined in this manner, and the wound in the choledoch duct is closed by suture or drainage externally is provided for. In the presence of irremediable obstruction of the choledoch duct, in consequence of impaction of a calculus or of an occluding tumor, or of compression by lymphatic glands, a suitable channel for the escape of the bile can be provided by establishing an artificial communication between the gall-bladder and the bowel.

Cholecystenterostomy.—The anastomosis is effected in accordance with the rules given in the description of entero-anastomosis (p. 304), with the aid of either sutures or the Murphy button. The communication is established between the gall-bladder and the jejunum (*cholecystojejunostomy*), or, if possible, between the gall-bladder and the duodenum (*cholecystoduodenostomy*). Artificial

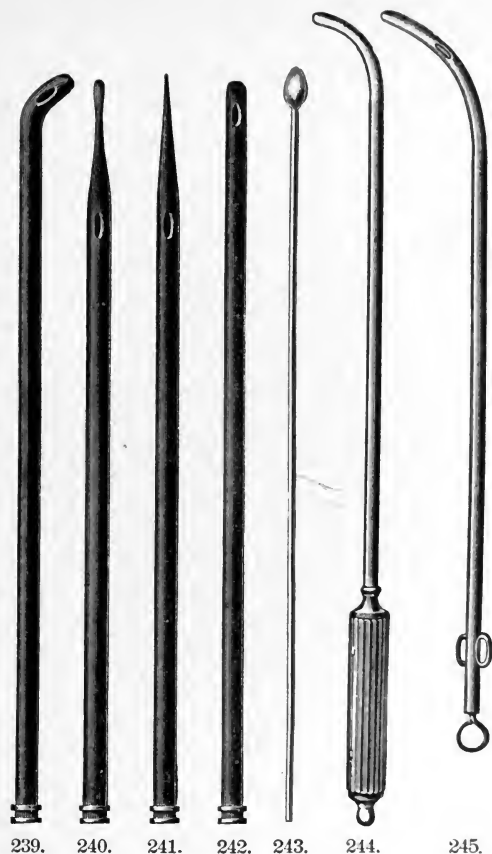
¹ If we desire the fistula to close subsequently, the gall-bladder should be sutured to the aponeurosis or peritoneum. If we wish the fistula to remain permanently, the gall-bladder should be sutured to the skin.—ED.

communication between the intestine and a dilated choledoch duct on the proximal side of an obstruction also has been recommended (*choledochoduodenostomy*).

Operations upon the Genito-urinary Organs.—
Catheterization.—From its external orifice to the entrance of the bladder the male urethra consists of three anatomically and functionally different parts, viz., the penile portion, the membranous portion, and the prostatic portion. The penile portion is surrounded by the corpus spongiosum of the urethra, which presents an enlargement at its anterior and posterior extremities, known respectively as the glans penis and the bulb of the urethra. The membranous portion, around which a sphincter of striated muscular fibers is arranged, penetrates the deep transverse perineal muscle stretched beneath the pubic arch, so that its proximal division, together with the prostatic portion, represents the intrapelvic part of the urethra. The membranous portion may be looked upon as the most fixed segment of the urethra. In front of it is the movable pendulous portion, and behind it, the prostatic portion is movable within slight limits. That portion of the urethra included between the external orifice and the sphincter of the membranous portion is known as the anterior urethra, that portion posterior to this as the posterior urethra, a distinction especially of clinical significance. The entire fixed portion of the urethra, from the mouth of the bladder to the bend of the penis, forms a large arch with its convexity backward. The base of the arch corresponds with the point at which the membranous urethra passes through the urogenital diaphragm.

Catheterization consists in proper instrumental evacuation of the contents of the bladder through the urethra. To effect this purpose tubular instruments are employed, which are made either of soft material or of metal, and are of varied shape. The choice of instruments will depend upon the conditions present in the individual case.

In performing catheterization the physician will, in accordance with the symptoms present and the results of



FIGS. 239-242.—Soft catheters of varying form.

FIG. 239.—Catheter coudé.

FIG. 240.—Conical and bulb-tipped catheter.

FIG. 241.—Conical and pointed catheter.

FIG. 242.—Cylindrical catheter.

FIG. 243.—Bulb-tipped sound for exploring the urethra and the bladder.

FIG. 244.—Massive steel sound (stone-sound) for exploration of the bladder.

FIG. 245.—Metallic catheter.

external and rectal examination and examination with an explorer (Fig. 243), form an idea of the condition of the urethra and determine accordingly the selection of a suitable instrument. Soft instruments, of vulcanized rubber or of impregnated woven silk, are made of varying thickness and are either straight or bent slightly at their vesical extremity. The former are cylindrical, conical, or bulbous at their vesical extremity (Figs. 239-242).

Catheters bent at their extremity at an angle (catheter coudé) are, notwithstanding their softness, well adapted, by reason of their shape, to overcome certain kinds of obstruction, principally dependent upon changed conditions of the prostate.

Rigid instruments made of metal are shaped in accordance with the configuration of the fixed portions of the urethra. The straight portion or shaft passes into a portion bent in conformity with the curvature of the posterior urethra. In the introduction of a soft flexible catheter the instrument accommodates itself to the shape and the course of the urethra and readily glides into the bladder. The rigid instrument is shaped in accordance with the curve of the urethra, although the correspondence is never complete. By delicacy in the manipulation of the instrument unavoidable distortion of the fixed portions of the urethra will be reduced to a minimum.

Mode of Introducing a Soft Catheter through the Urethra into the Bladder.—The patient lies upon his back, with the pelvis somewhat elevated, and the operator stands upon the left side. The penis is grasped with the left hand and raised in such a way that the pendulous portion of the urethra is rendered tense, and the catheter is introduced into the urethra and gently pushed forward. The catheter coudé is so introduced that its beak is directed toward the upper wall of the urethra. In passing the membranous portion a sense of slight resistance is appreciated, which is overcome by gentle pressure. From this point the beak of the instrument slips into the bladder without further obstruction. In the presence of hypertrophy of the

prostate and of elongation of the prostatic portion of the urethra the catheter must be introduced for a greater distance, often up to its hilt, before urine flows. After the flow of urine has ceased the residual urine in the bladder will escape after slight withdrawal of the soft catheter.

The introduction of a rigid catheter into the bladder is a much more difficult procedure, and its safe and proper

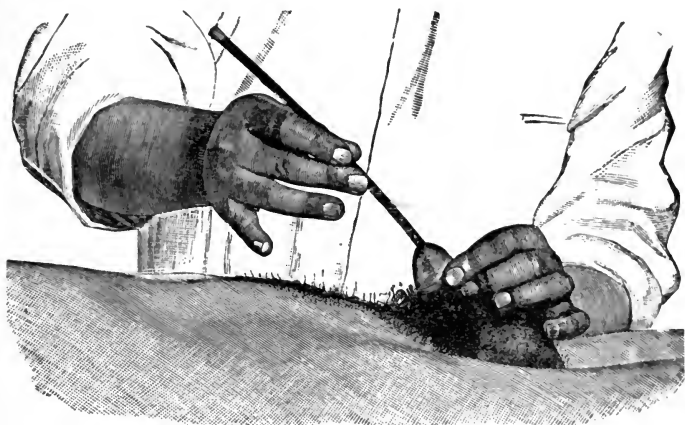


FIG. 246.—Method of introducing a partially rigid catheter.

execution requires a certain amount of skill. In general the rule observed is to make the beak of the instrument pass along the upper wall of the urethra. If the urethra be normal, no difficulty is experienced in the operation until the membranous portion is reached, but at the junction of the movable with the fixed membranous portion a slight obstruction is encountered by the beak of the catheter (Fig. 247). Care must now be taken to prevent the tip of the instrument catching in the mucous membrane. The beak must therefore not deviate from the median line, and with cautious movements and with-

out any violence the instrument should be passed into the membranous portion. After the resistance has been overcome the instrument will be felt to enter the membranous portion and pass through the urogenital diaphragm.

From this point the catheter in a normal urethra encounters no further obstruction, and, on depressing the handle of the instrument, the tip enters the bladder without further hindrance (Fig. 248).

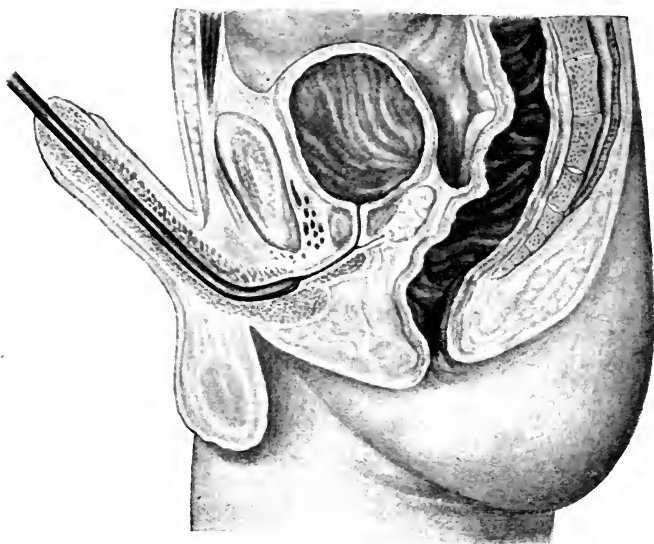


FIG. 247.—Introduction of a rigid instrument, the tip of the catheter obstructed at the bulb of the urethra.

In catheterization by this method the patient is placed horizontally upon his back, with the pelvis somewhat elevated, and the operator standing upon his left side. The penis is grasped with three fingers of the left hand, and the lips of the urethra are held apart by means of the thumb and the index-finger. The catheter or the solid sound is grasped at its distal extremity with the first three

fingers of the right hand. The palmar aspect of the hand is turned upward, and the little finger rests upon the middle line of the abdomen (Fig. 249).

The operator enters the beak of the instrument into the urethra and draws the penis, with a certain degree of tension, over the curve of the catheter, which is at the same time being steadily kept in the middle line and gradually raised until it reaches a vertical position. With

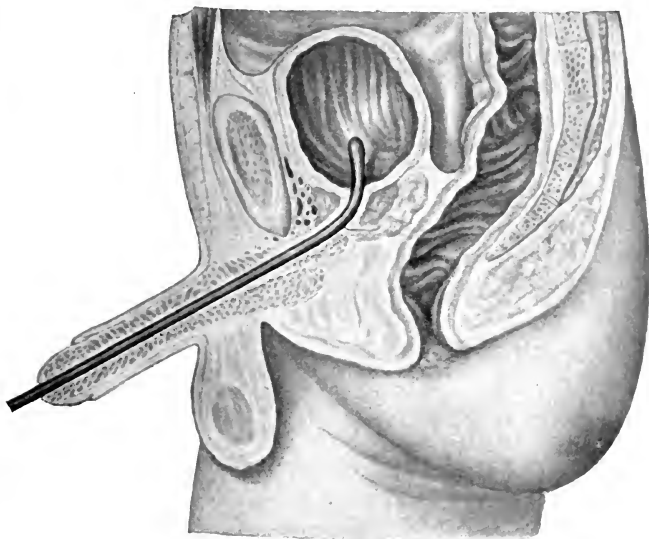


FIG. 248.—Introduction of a rigid instrument into the bladder: by depressing the shaft of the catheter its beak is made to glide into the bladder.

a slight jerk the tip of the instrument passes the bulbous portion and it yet remains to traverse the membranous portion and pass the urogenital diaphragm.

In all cases a sense of obstruction is encountered at this point which is readily overcome by gentle pressure when one feels sure that he is on the right way, while the catheter is held accurately in the median line, and is

gradually depressed from the vertical to the horizontal toward the lower extremities (Fig. 251).

If the instrument is at the same time pushed forward slightly, its tip enters the bladder. At this moment urine will escape from the catheter. With the rigid instrument, as soon as the prostate has been passed and the bladder has been entered, free movements can be made with the tip of the instrument.

The method of introducing the catheter described is

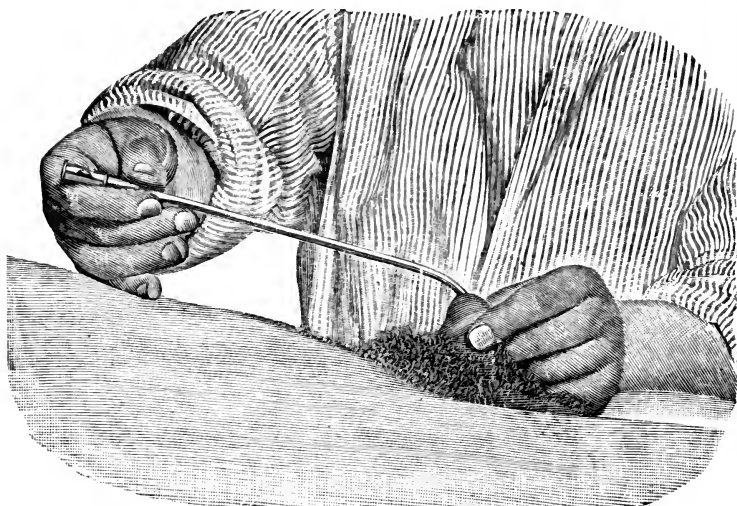


FIG. 249.—First position in the introduction of the catheter.

attended with difficulty in obese individuals and in the presence of meteorism and ascites. Under such circumstances it seems desirable to enter the catheter at right angles to the axis of the body, with the penis raised vertically. In this position the instrument is pushed forward and at the same time rotated in an arc to the median line and elevated to a vertical position until the tip is grasped by the bulbous portion (Fig. 252). In another mode of

FIG. 250.—The catheter is elevated at a right angle to the trunk; an effort is made to enter the tip into the membranous portion of the urethra.



procedure the operator sits before the patient, who is placed in the position for the operation of cutting for stone. The catheter, with its vesical extremity directed toward the patient, is introduced into the orifice of the urethra with its convexity directed upward. The penis, raised vertically, is drawn over the curve of the catheter, and the instrument is rotated through an arc of 180 degrees toward the right until it reaches the median line.

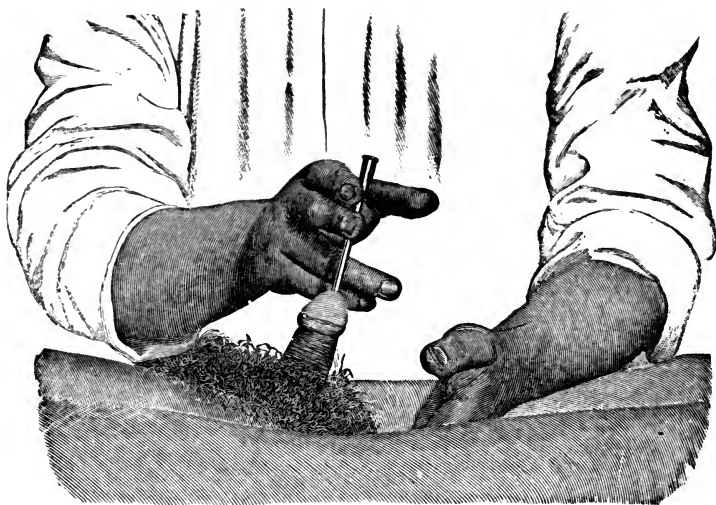


FIG. 251.—Catheterization: the catheter has entered the membranous portion and has passed the urogenital diaphragm; by depressing the handle the tip enters the bladder.

During the progress of these manipulations the beak of the instrument enters the urethra to the bulbous portion. Now, the handle of the catheter is elevated and pushed forward in the median line until its beak has passed the posterior urethra and entered the bladder.

In a normal urethra an instrument of considerable weight, as, for instance, a rigid sound of large caliber (lithotripter), overcomes readily the obstruction encoun-

tered on the distal side of the bulbous urethra and glides easily, by reason of its own weight, into the bladder, without further guidance. The guiding hand need only prevent the departure of the instrument from the median line. In the presence of narrowing, however, a certain amount of pressure in the direction of the urethra is necessary, in order to urge the instrument onward through the rigid cicatricial tissue. If the urethra is narrowed in



FIG. 252.—Mode of introducing the catheter from the side.

its deeper portion, or if the prostate is enlarged, it will often be necessary to introduce the index-finger of the left hand into the rectum as a guide. In the presence of hypertrophy of the prostate, on account of elongation of the prostatic portion of the urethra, and on account of elevation of the orifice of the bladder, the catheter or the sound must be introduced for a greater distance and be more greatly depressed, in order that the beak may reach into the bladder.

Catheters for introduction into the female urethra correspond with the shortness of this canal, and are either straight or slightly curved at their extremity. In catheterization the labia are separated, the instrument is introduced into the urethra, and the handle is depressed while the catheter is pushed forward. Only in the presence of

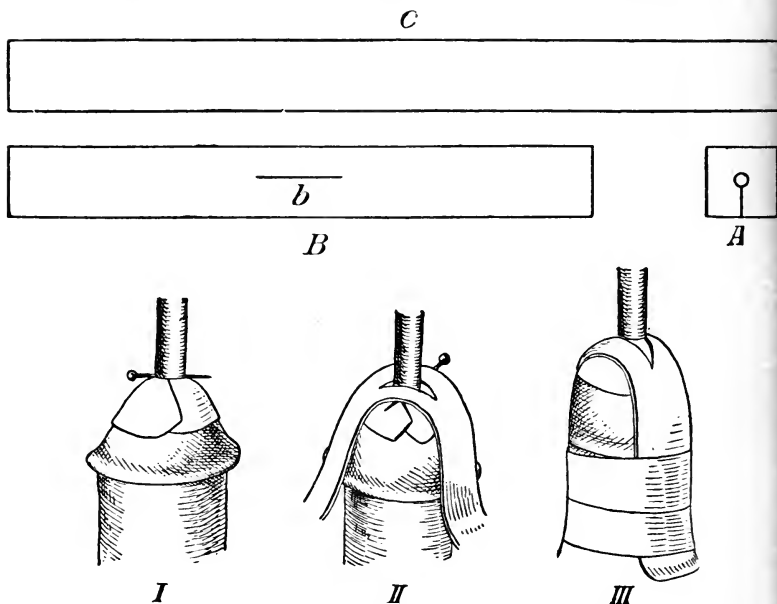


FIG. 253.—Fixation of the retention-catheter: *A*, *B*, *C*, forms of the strips of adhesive plaster; *I*, *II*, *III*, modes of applying the plaster to the penis.

pregnancy or of tumors of the genital organs may the female urethra be elongated or distorted. The resulting difficulty in the introduction of a catheter is to be overcome by the employment of partially rigid instruments, as in males.

Retention-catheter.—A catheter may be permitted to remain within the urethra for days or even weeks. In

order to serve its purpose permanently it must be suitably fixed in position. The introduction of a retention-catheter into the urethra permits constant escape of urine, and the muscular layer of the bladder is thrown out of function; further, the wall of the urethra is not brought into contact with the urine. Such a form of catheter is therefore employed when it is desired to place the bladder at rest, to secure a permanent channel of escape for the urine, and finally to exclude the urethra from the irritation of passing urine. The moderate but constant pressure of the retention-catheter softens cicatrices of the urethra and exerts a



FIG. 254.—Retention-catheter of Pezzet.

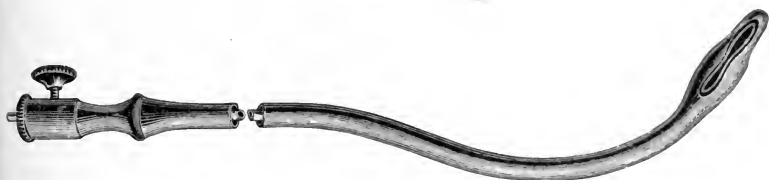


FIG. 255.—The catheter of Pezzet adjusted over a mandarin.

dilating influence upon circular strictures, and for this reason is applicable with advantage in the presence of callos and cicatricial strictures of the urethra. Finally, the retention-catheter is to be recommended when catheterization that must be frequently repeated is attended either with difficulty or with unpleasant results, such as hemorrhage and urinary fever. The soft catheter of vulcanized rubber is, as a rule, employed as a retention-catheter. The instrument is introduced to a sufficient depth for the urine to escape without interruption. A suitable pin is passed transversely through the catheter just in advance of the orifice of the urethra and its point broken off. Strips of

adhesive plaster are prepared in the manner indicated in Fig. 253. The square incised strip with an opening at its center is applied upon the glans in such a way that it supports the pin passing through the catheter (Fig. 253, *I*). The longer strip, slit in the middle, is drawn over the catheter, and comes to rest upon the needle, being made to adhere to the sides of the penis (Fig. 253, *II*). The entire arrangement is made secure by circular turns of strips of plaster passing around the organ from the glans to the root (Fig. 253, *III*).

Fixation apparatus can be dispensed with if the catheter of Pezzer (Fig. 254), provided with a shoulder at its vesical extremity, is introduced. In order to be passed into the bladder the catheter is adjusted over a wire mandarin (Fig. 255).

Puncture of the Bladder.—Evacuation of the bladder through a suprapubic puncture is undertaken as a palliative measure, and also for the purpose of forming a vesical fistula through the abdominal wall. The methods formerly practised of puncturing the bladder through the perineum and through the rectum are at present not employed. Palliative puncture of the bladder is practised in the presence of complete retention of urine in consequence of impermeable stricture of the urethra, when it is desired to await a more favorable time for the introduction of a sound into the urethra, or for the performance of a radical operation for the relief of the obstruction. For the purpose of establishing a vesical fistula the operation is undertaken (1) in the presence of prostatic enlargement, with complete or incomplete retention of urine, when catheterization is attended with difficulty or is followed by hemorrhage; (2) when the mouth of the bladder is obstructed by a tumor that cannot be removed by operative measures; (3) to effect drainage of the bladder in cases of severe purulent cystitis. If the object of the procedure is only evacuation of the bladder, the puncture is made with a thin, so-called exploratory trocar. The operation is in itself of little significance and, if necessary,

can be frequently repeated. The patient lies upon his back, with the pelvis somewhat elevated. As the puncture is always undertaken by reason of retention of urine, the bladder is distended to the maximum, and is readily palpable as a tumor above the symphysis pubis. The operator stands to the right of the patient, and marks with the tip of his left index-finger a point in the middle line just above the symphysis where the puncture is to be made. The trocar is pushed vertically through the abdominal wall, disappearance of the sense of resistance indicating that the point of the instrument has entered the bladder. The cannula is grasped with the thumb and the index-finger of the left hand and the stilet is removed with the right. After the urine has escaped, the cannula is removed, its extremity being closed with the tip of the thumb in order that the wound be not contaminated. The wound of puncture invariably heals without complication.

If in conjunction with puncture a vesical fistula is to be established in the abdominal wall the operation is to be performed with the aid of the semicircularly curved trocar of Frère Côme (Fig. 256). The position of the patient and of the operator is the same as that just described. The index-finger of the left hand marks the point accurately in the middle line just above the symphysis, where the puncture is to be made. The instrument

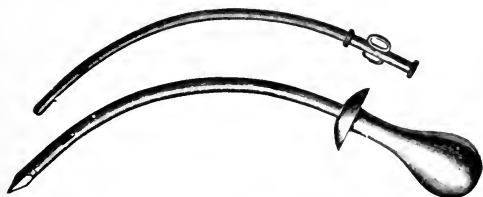


FIG. 256.—Trocar for puncture of the bladder, after Frère Côme.

is applied vertically and pushed forcibly through the abdominal wall. When the disappearance of resistance

indicates that the abdominal wall has been passed the instrument is pushed onward and its handle is raised so that its extremity is directed toward the fundus of the bladder. The stilet is now removed (Fig. 258) and a suitable tube passed through the cannula. The cannula remains in place for about a week, after which a Nélaton

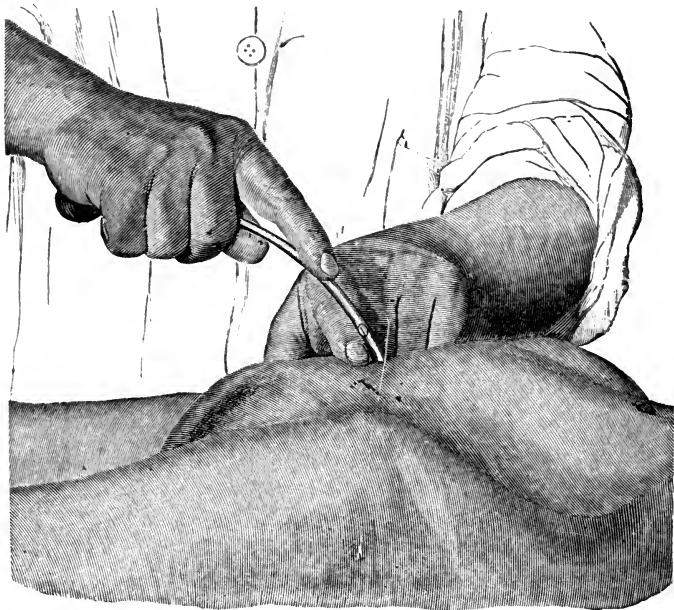


FIG. 257.—Puncture of the bladder: position for making the puncture.

catheter is introduced into the fistula and fixed in the wound.

External Urethrotomy.—External urethrotomy consists in entering the urethra through an incision in the perineum. The operation is undertaken (1) in the presence of calculi and foreign bodies in the urethra, whose removal cannot be effected through the natural passages; (2) in the

presence of injuries of the urethra ; (3) in the presence of strictures of the urethra which are either impermeable or not accessible to treatment by dilatation for other reasons ; (4) for the establishment of a urethral fistula ; (5) as a preliminary operation to median section for stone.

The mucous membrane of the pendulous urethra is readily reached with the knife after division of the skin, the dense fascia, and the corpus spongiosum. The bulb of the urethra is accessible in the middle line through an

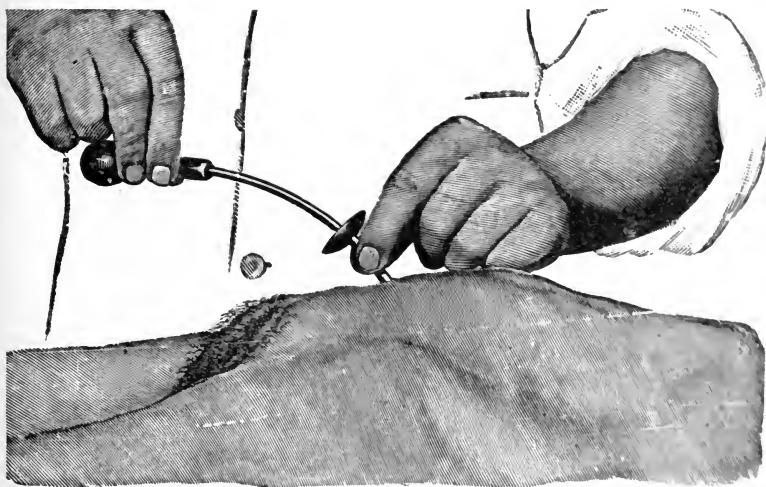


FIG. 258.—Puncture of the bladder : removal of the trocar.

incision in the perineal raphe, after division of the skin, the tunica dartos, the superficial perineal fascia, and the bulbocavernosus muscle. The corpus spongiosum is thicker in this situation than elsewhere, so that the urethra can be opened only at a considerable depth. To the central side of the bulb the urethra recedes more and more from the superficial level of the perineum, passing in an arch upward and backward to the orifice of the bladder. The rectum lies with its anterior wall in close relation to the posterior

aspect of the prostate gland, and is indirectly attached to the bulb of the urethra at its perineal curve through some fibers of the sphincter ani and bulbocavernosus muscles. If it is desired to reach the membranous or the prostatic portion, the muscular and fibrous connections between the anus and the prostate gland must be divided transversely, when, after blunt dissection of the rectum, which is reflected toward the sacrum, the proximal portions of the urethra, the membranous portion, and the prostate are rendered visible and accessible to surgical intervention.

The performance of external urethrotomy is subject to various modifications in accordance with the indications for the operation. The patient lies upon his back with the lower extremities flexed at the knee and the hip (position for cutting for stone). The operator is seated in front of the patient. The urethra is invariably opened in the median line through the raphe of the perineum.

External Urethrotomy with a Guide.—A metallic sound grooved upon its convexity is introduced into the urethra to a point beyond the constriction that is to be divided. The guide is held by an assistant accurately in the middle line. If the incision is to be made into the perineum, the scrotum is lifted up. The operator determines by touch with the finger the position of the resistant portion of the urethra, which is perhaps a callous stricture, and makes an incision over it in the middle line. If the narrowing be at the junction between the bulbous and membranous portions, the incision passes from the root of the scrotum almost to the margin of the anus. By dissecting layer by layer in the median line the callous and narrowed portion of the urethra is reached and an incision is made in the line of the cutaneous wound until the groove in the guide is exposed. The callus is divided up to a point where the urethra is of normal caliber. The introduction of a retention-catheter concludes the operation.

Urethrotomy without a guide is an incomparably more difficult operation than that just described. The operator occupies the same position as in cutting for stone. The

sound can be introduced only to the anterior portion of the stricture if this be impermeable. The cutaneous incision is made, as in the operation just described, in the median line through the perineal raphe. The portion of the urethra lying to the distal side of the constriction is incised, and the margins of the wound are separated by means of small retractors. An effort is made to find the lumen of the constriction and to gain entrance by means of a thin bulbous probe. If this can be done, the cicatricial tissue is divided in the middle line and on its under surface down to the probe, and the incision is continued beyond the narrowing of the urethra.

As a rule, the detection of the canal of the urethra at the distal extremity of the stricture is attended with difficulty. The tissues are changed from the presence of cicatrices, and the hemorrhage from the cavernous bodies and from the bulb is often considerable, so that it can be readily understood that the small lumen of the urethra may escape detection in the limited field of operation. Indiscriminate incision into the callous area is not to be commended. By means of manual expression of the bladder it may be possible, under some circumstances, to cause the escape of a few drops of urine into the wound and in this way to gain an idea as to the situation of the orifice of the stricture. If it has been possible by this means, under guidance of the eye, to introduce a bulbous bougie into the orifice of the stricture, the division of the narrowed portion of the urethra will be unattended with any further difficulty.

After division of the stricture a catheter of considerable caliber can always be introduced from the meatus and with aid from a finger in the wound be passed through the entire urethra into the bladder. In the event of failure to divide the stricture through the wound there remains yet the resource of retrograde sounding of the stricture, *posterior catheterization*. This may be undertaken:

(1) *Through the urethra*, after exposure and incision of the urethra to the proximal side of the stricture;

(2) *Through the bladder*, after this has been opened by means of a suprapubic incision.

In performing retrograde catheterization through the urethra the deeper portions of this canal (the membranous portion) are exposed by detaching the lowermost extremity of the rectum. To this end the perineal longitudinal incision is either prolonged to the anus or the detachment of the rectum is undertaken through a pre-rectal curved incision. After division of the skin the connections between the sphincter ani and the bulbocavernosus muscles are divided transversely and then the anterior wall of the rectum is freed by blunt dissection from the cutaneous covering. If the bulb of the urethra is retracted upward and the rectum downward, the membranous portion can be dissected in the upper angle of the wound. The membranous portion, which is readily palpable as a rounded prominence, is incised longitudinally for a distance of about 1 cm., and retrograde sounding can be practised through the narrowed portion, which is then divided.

Retrograde sounding of the stricture can be practised also from the bladder, after this has been opened through a suprapubic incision. The patient lies upon his back, with the pelvis elevated, and the bladder is opened in the usual manner above the symphysis pubis. The incision in the bladder is held open by retractors, and an English catheter of small caliber is pushed forward under the guidance of a finger through the neck of the bladder into the urethra to the point of obstruction. The patient may be placed in the position as for the operation for stone, the wound in the perineum held open by retractors, and the stricture is passed or merely entered by pushing the catheter forward from the bladder. In the first event the stricture is divided down to the catheter; in the second, the portion of the urethra lying to the proximal side of the stricture is opened and the stricture itself is successively divided with scissors from behind forward. The last step is, as a rule, effected without difficulty.

External urethrotomy must be performed after *traumatic rupture of the urethra*, complete or incomplete, when catheterization is attended with difficulty, or urinary infiltration is threatened. The operation is performed in such a manner that the incision is made through the perineum in the raphe, over the greatest prominence of the perineal bulging that is always present. After division of the skin and the superficial fascia entrance is gained to the wound-cavity filled with blood-clots. The wound is carefully explored in all its parts; the peripheral stump is always readily found, while the central extremity of the urethra is frequently retracted, though often enough visible free in the wound.

Primary suture is but rarely practised, on account of the contused state of the extremities of the urethra. A soft catheter is introduced through the orifice of the urethra into the wound and passed through the central stump into the bladder, and fixed in place, the wound-cavity being tamponed.

The simplest form of urethrotomy is practised in cases in which a stone or foreign body in the urethra is to be removed through an incision from without. The incision is made upon the under surface of the urethra, directly upon the palpable foreign body. The mucous membrane is opened by a linear incision, the stone extracted, and the wound in the urethra closed by suture. The fascia and the skin are closed by a second layer of sutures. A retention-catheter is introduced.

Internal Urethrotomy.—Internal urethrotomy, division of a stricture from the lumen of the urethra, is indicated in the presence of:

- (1) A contracting stricture.
- (2) Narrowing, with consecutive disease of the urinary passages, if dilatation is always attended with fever, exacerbations of an existing cystitis, etc.
- (3) Complete retention of urine in consequence of stricture, especially in all cases in which the rapid restoration of a large urethral caliber is strongly indicated.

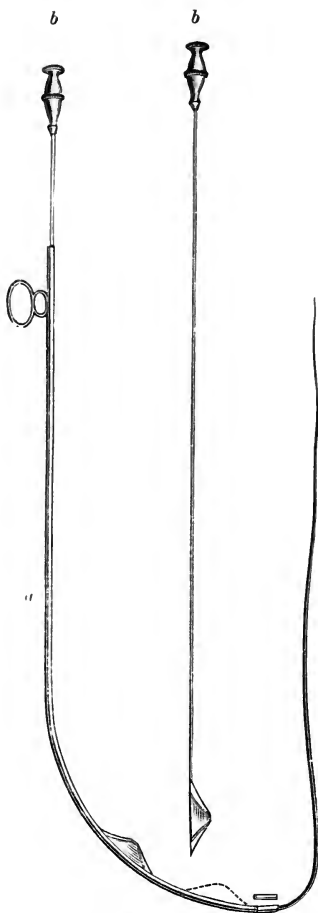
Mode of Performing Internal Urethrotomy:

FIG. 259.—Maisonneuve's urethrotome: *a*, guiding sound, armed with a filiform bougie; the knife (*b*) is pushed forward in the groove of the guiding sound.

(1) Introduction of a filiform bougie, to whose extremity is attached the rigid sound provided with a groove for the knife (Fig. 259, *a*).

(2) The cannulated sound is passed through the stricture into the bladder, according to the rules for catheterization with rigid instruments (Maisonneuve's catheterisme à la suite).

(3) The blade of the urethrotome (Fig. 259, *b*) is introduced into the canal of the guiding sound and pushed forward to the stricture; by pressure upon the end of the blade the stricture is divided through the upper wall of the urethra.

(4) After removal of the blade, the guiding sound is removed for a sufficient distance from the urethra to be unscrewed. It is replaced by the filiform bougie of a straight guide, over which the catheter is introduced. When this has entered the bladder, the guide and the filiform bougie are removed. The catheter is fixed and remains in place.

Lateral Perineal Incision for Stone.—The patient is

placed in the usual position for stone-operations, with the operator sitting in front. A convex grooved sound is introduced into the urethra and held vertically by an assistant, with the groove directed immovably toward the left. The incision passes from the middle of the perineal raphe to a point midway between the anus and the left ischial tuberosity. Deep dissection is proceeded with, the position of the groove in the guide being constantly kept in mind. After the deeper layers of the perineum (superficial and deep perineal fascia, superficial transverse perineal muscle) have been passed and the urethra has been opened upon one side (avoiding the bulb), the groove of the instrument will come into view in the wound. The operator grasps the guide with his left hand and introduces into the wound a blunt-pointed knife, with its edge directed downward, in such a manner that it lies with its back directly against the guide. While the handle of the guide is depressed, the operator divides the membranous portion up to the prostatic portion with the blunt-pointed knife (lithotome), which he pushes forward in the direction of the urethra. At this moment the contents of the bladder stream into the wound by the side of the guide. The wound-canal is enlarged instrumentally or with the finger, which is permitted to enter the bladder, and the calculus is extracted with stone-forceps or a stone-spoon. In the after-treatment a catheter is permitted to remain in the urethra and the wound is tamponed.

Median Section for Stone.—The details for the operation are precisely like those just described. The guide is held accurately in the median line, with its groove directed forward. The cutaneous incision passes through the perineal raphe, beginning just behind the attachment of the scrotum and extending for a distance of 5 or 6 cm. toward the anus. The knife is introduced deeply in a vertical direction, an endeavor being made to reach the membranous portion of the urethra, with avoidance of the bulb. The urethra is opened in the median line and the incision is prolonged, as in the operation just described, by

means of the blunt-pointed knife to the prostatic portion. The stone is now removed in the typical manner.

The lateral and median incisions for stone, which in the past were the customary operations, possess to-day but a limited field of application, having been almost completely displaced by the suprapubic incision. [Displaced particularly by litholapaxy.—ED.] The median incision, the more recent of the two, was chosen in order to avoid the division of the ejaculatory ducts that has been observed repeatedly as a result of the lateral incision. Both methods are attended with the disadvantage that the removal of large stones through the narrow wound-canal can be effected only with difficulty, so that the wound itself is distorted and lacerated in the efforts at extraction and dilatation, and the conditions for recovery are rendered unfavorable. Finally, a typical form of true incontinence, permanent dribbling of urine, is not rarely observed after the median or the lateral incision, even when union has proceeded smoothly.

Urethrostomy.—In cases of incurable stricture Poncet excludes entirely the narrowed portion of the urethra by means of perineal urethrostomy, dividing the urethra on the proximal side of the stricture and permitting it to open upon the perineum. The stricture is exposed by means of the usual incision through the perineal raphe, when the urethra is divided transversely on the proximal side of the stricture, and is sutured in the lower angle of the cutaneous wound. Poncet divides the central stump throughout a slight extent on its under side before suturing it in the wound. The peripheral stump of the urethra is sutured and dropped into the wound, when the cutaneous wound is closed by suture up to the opening of the fistula.

Litholapaxy.—Instrumental endovesical crushing of stone in the bladder, followed immediately by evacuation of the fragments, is designated litholapaxy. The instrument for destroying the stone is made of steel, shaped like a catheter, and consists of two blades fitting one into the other and the tip of one of which is serrated



FIG. 260.—Instrument for crushing stone in the bladder.

(Figs. 260, 261). The instrument grasps the stone between its two blades, which can be secured firmly and are brought together by means of a screw-mechanism; the stone, thus grasped, is crushed between them. To attain good results with the operation of litholapaxy a careful selection of cases, as well as skill in the use of the instrument, is required.

Mode of Procedure.—The patient occupies the dorsal decubitus, with the pelvis somewhat elevated. The blad-

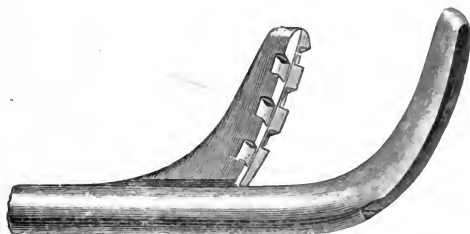


FIG. 261.—Beak of the lithotrite, natural size. English bite.

der is filled moderately with sterile solution of boric acid. The lithotrite is introduced according to the rules laid down for catheterization, the operator standing upon the right side of the patient. An attempt is made to touch the stone with the tip of the closed instrument, when the blades are separated to grasp the stone. When the stone is caught, the blades of the instrument are fixed by means of a sliding arrangement on its handle, and the stone is crushed by means of the

screw mechanism. Now, the individual fragments of the broken calculus are grasped separately and are crushed. Finally, the residue is converted into a fine powder by crushing. A rigid evacuating catheter is introduced and

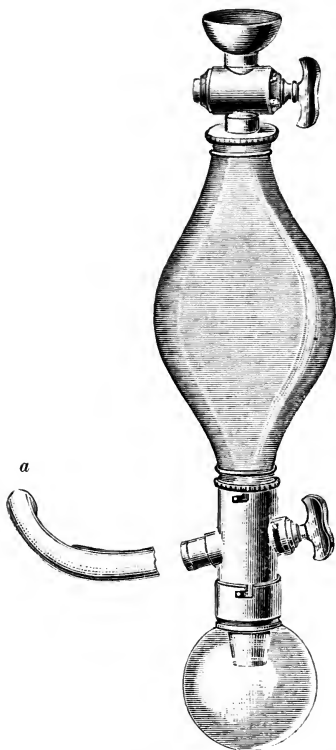


FIG. 262.—Bigelow's pump: *a*, beak of the evacuating catheter.

the bladder is irrigated, with the escape of sand. With the bladder moderately full the evacuation-catheter is connected with a pump (Fig. 262), whose activity is continued as long as fragments of stone are present in the bladder. If a rather large fragment of stone can be felt, this must be reduced further in size by means of the lithotrite. The cystoscope permits confirmation by ocular inspection of the fact that complete evacuation of the fragments has been effected. With a proper selection of the cases the results of litholapaxy are admirable.

Operations on the Bladder.—The bladder, situated in the true pelvis just behind its anterior wall, is attached to the pubic arch through the prostate gland and the pubovesical ligaments. Be-

sides, the organ is held in place within certain limits by the visceral layer of the pelvic fascia (endopelvic fascia), by the vesico-umbilical ligaments, and by the peritoneum. The peritoneum passes from the anterior abdominal wall

and from the lateral walls of the pelvis upon the bladder, whose fundus and posterior and lateral walls it covers. When empty, the bladder is concealed behind the symphysis. When filled, the upper portion rises above the pelvic brim, so that the anterior wall of the bladder not covered by peritoneum comes to lie in immediate juxtaposition with the abdominal wall. The bladder, if filled to the maximum, can thus be opened above the symphysis without injury to the peritoneum.

Suprapubic Cystotomy.—This consists of opening of the bladder through its anterior wall above the symphysis pubis.

The operation is indicated :

- (1) In the presence of calculi and other foreign bodies in the bladder ;
- (2) In the presence of tumors of the bladder ;
- (3) In the presence of tuberculosis of the bladder ;
- (4) In cases of vesical hematuria ;
- (5) In cases of rupture of the bladder ;
- (6) For the removal of hypertrophied lobes of the prostate gland ;
- (7) For the purpose of forming a fistula ;
- (8) In cases of severe cystitis ;
- (9) As a preliminary operation in the performance of posterior catheterization.

The mode of procedure is subject to various modifications in accordance with the indications for its performance. Three types of operation are distinguished :

- (1) Simple opening of the bladder for the removal of calculi and other foreign bodies ;
- (2) Opening of the bladder for the purpose of undertaking endovesical manipulations (extirpation of tumors, etc.) ;
- (3) Opening of the bladder for the purpose of establishing a fistula.

In all cases the bladder is distended to the maximum by the injection of fluid into its cavity, so that it rises above the level of the symphysis. If it is impossible

thus to fill the bladder, the anterior wall of the viscus is forced into the wound by means of a concave grooved guide and incised.

1. *Suprapubic Cystotomy for Stone.*—The patient occupies the dorsal decubitus, with the pelvis somewhat raised by means of a pillow, and the operator stands to his right side. After the abdominal wall has been cleansed and shaved, a catheter is introduced and the bladder is irrigated until the escaping fluid is clear. Sterile fluid

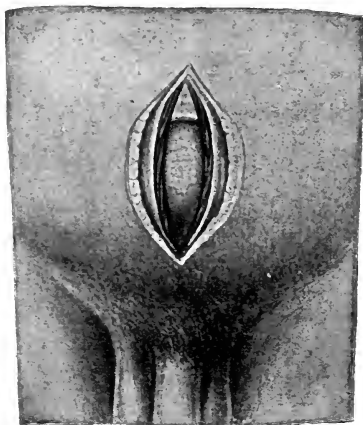


FIG. 263.—Suprapubic cystotomy: the anterior wall of the bladder is exposed; near its summit is the point of reflection of the peritoneum.

is now permitted to flow into the bladder through an irrigator or a sufficient quantity is injected to cause the bladder to become palpable as a tense swelling above the symphysis pubis. The catheter is removed and the penis is tied with a strip of gauze. The incision is made in the linea alba just above the symphysis, and is from 5 to 7 cm. long. Passing directly to the depth of the wound the fatty layer is traversed and the anterior rectus sheath or the fibrous linea alba is divided. The rectus muscles are retracted, and in the space of Retzius

thus exposed the bladder is palpable as a tense mass. The prevesical fat is displaced from the bladder by blunt dissection by means of two pairs of forceps, until the anterior wall of the viscus, recognizable by the difference in color and by the bundles of muscles and veins upon its surface, is exposed (Fig. 263).

Just below the transverse line of reflection of the peritoneum a simple pointed tenaculum is introduced into the wall of the bladder, which is divided in the median line with a sharp-pointed knife, in the direction of the symphysis. The margins of the wound are held apart by means of two retractors. The operator introduces the index-finger of his left hand into the bladder, touches the stone or the foreign body, and causes the beak of the stone-forceps to follow the palmar aspect of the finger to the calculus. The blades of the forceps are now separated, and the stone is grasped and removed from the wound. The wound in the wall of the bladder can be closed at once by suture. Various complicated methods of suture of the bladder have been abandoned. We close the wound in the viscus by one or two rows of interrupted catgut sutures, including the entire thickness of the wall of the bladder, with the exception of the mucous membrane.

Fixation of the sutured bladder to the abdominal wall (*cystopexy*) is not without advantage. If suture of the wall of the bladder is deferred, the wound in the viscus should be permitted to remain open. The urine is drained permanently by siphonage (Dittel's angular tube, Guyon's tube-siphon, etc.), and the bladder is by this means kept perfectly at rest.

2. *Suprapubic Cystotomy for the Purpose of Undertaking Intravesical Manipulations.*—If opening of the bladder is effected as a preliminary procedure to facilitate intravesical manipulations, it is best to raise the pelvis as high as possible. The preparations for the operation and the opening of the bladder are made in the manner already described. Peterson's balloon, introduced into the rectum

Plate 36.—Suprapubic Cystotomy with the Pelvis Elevated.

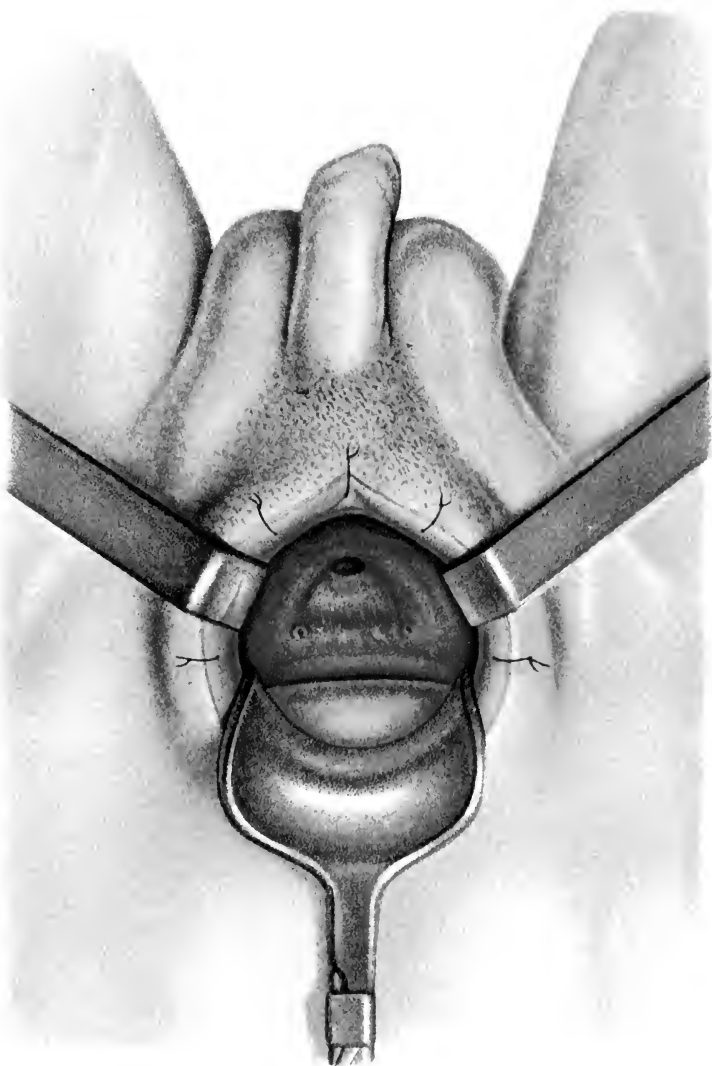
The wound is enlarged by the introduction of retractors, and the interior of the bladder is rendered visible. The wall of the viscus has been provisionally attached to the skin by sutures. There may be observed the mouth of the urethra, the trigone, and the entrances of the ureters. The wall of the summit of the bladder appears as a prominence above the broad speculum.

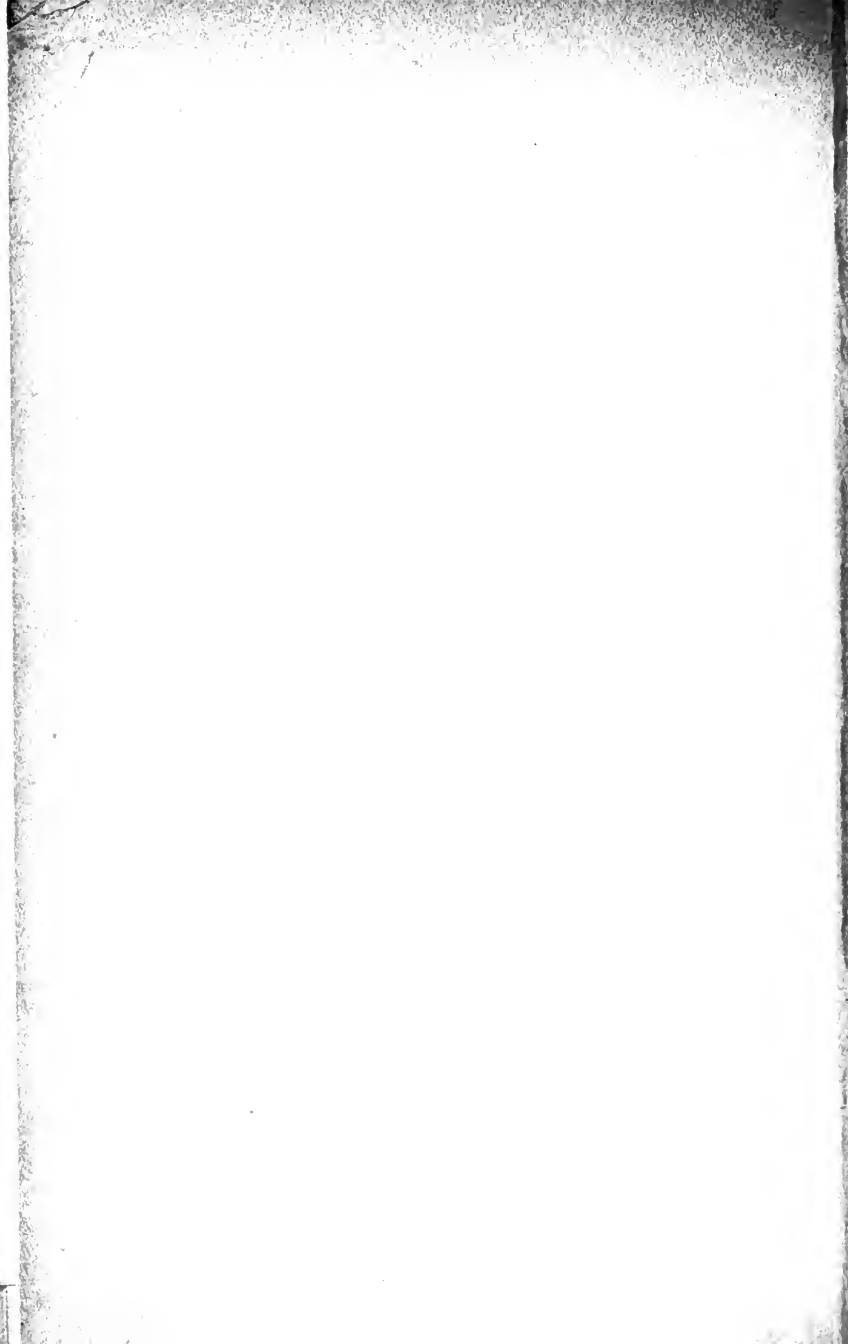
and distended with water, can be employed with advantage to raise up the fundus of the bladder if this is to be operated on. In place of the longitudinal incision previously described, a transverse cutaneous incision and a transverse opening into the bladder can be made if especially free access to the bladder is desired. In this event the rectus muscles are divided transversely in the wound (Fig. 264). Nevertheless, the ordinary longitudinal incision provides sufficient room, for instance, for extirpation of tumors of the bladder. After the bladder has been opened a view of its interior should be possible. To this end the margins of the wound in the bladder are held apart by means of broad retractors resembling lateral vaginal specula, while a broad Simon speculum is introduced in the upper angle of the wound. If, besides, the interior of the viscus is illuminated by means of an incandescent lamp, inspection is readily possible and the operator may undertake a variety of manipulations within the cavity of the bladder (excision of tumors, control of hemorrhage, suture of deficiencies in the mucous membrane, curetting, etc.) (Plate 36).

If after extirpation of vesical tumors bleeding has been completely controlled, the bladder may be closed by suture. After the extirpation of malignant tumors, and after operations upon the prostate, drainage of the bladder should be maintained for a time.

By making a transverse incision through the skin and opening the bladder in the same manner, after division of the rectus muscles, generous access to the interior of the viscus is possible.

Suggestions have been made by a number of operators





to expose the bladder throughout a greater extent by means of operations upon the bony parts. To this end Helferich resects a triangular portion of the symphysis pubis, while Bramann recommended temporary partial resection of the symphysis, and Niehans lateral resection of the pelvis.

3. *Section of the Bladder for the Purpose of Establishing a Fistula.—Cystostomy.*—In the performance of cystostomy a short longitudinal incision is made above the symphysis

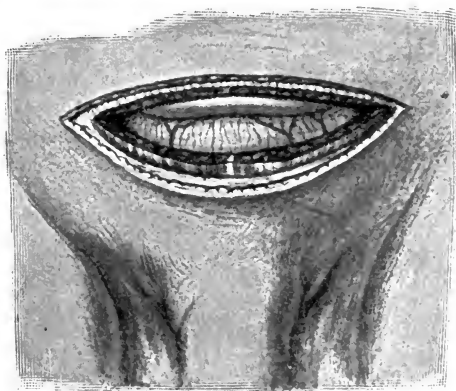


FIG. 264.—Exposure of the bladder by means of a transverse incision. The rectus muscles are divided; the bladder, recognizable from its muscular fibers and veins, is visible, and over it the line of reflection of the peritoneum.

pubis according to the method of Poncet, and the bladder is opened in the usual manner. The lips of the wound in the wall of the bladder are brought to the level of the skin, and attached on either side to the margins of the skin by sutures. The cutaneous wound is closed in its upper portion, while the vesical mucous membrane is sutured in the lower portion. The establishment of a fistula may be effected also without previous suture of the vesical mucous membrane, by the employment of simple siphon-drainage. The angular tube may in the further

course of the case be replaced by a soft catheter, which is introduced into the bladder through the wound and is permitted to remain.

Operations on the Kidneys.—Operations on a kidney may be undertaken :

1. For the purpose of opening the kidney by incision—*nephrotomy* ;

2. For the removal of the totally diseased kidney—*nephrectomy* ;

3. For fixation of a movable kidney—*nephropexy* ;

4. For the exsection of portions of the kidney—*resection of the kidney*.

Nephrotomy and Nephrectomy.—Nephrotomy is indicated in the presence of—1, simple pyonephrosis ; 2, stones in the pelvis of the kidney, if sufficient functionally active parenchyma remains ; 3, severe renal hematuria ; 4, hydronephrosis.

Nephrectomy is indicated in the presence of : 1, severe pyonephrosis, if the kidney is transformed into a series of pus-cavities (calculi, tuberculosis of the kidney) ; 2, injuries of the kidney (rupture, laceration) ; 3, tumors of the kidney ; 4, incurable ureteral fistulæ.

For exposure of the kidney the patient is placed upon the healthy side of his body over a cylindric pillow (Fig. 265). The cutaneous incision (König) begins at the angle between the twelfth rib and the erector spinæ, and passes thence vertically downward toward the crest of the ilium and along this almost to the anterior superior spine. Skin, fat, lumbodorsal fascia, and the fibers of the latissimus dorsi are divided, in order that, after division of the deep layer of the fascia, the quadratus lumborum and, in the anterior portion of the wound, the triplicate layer of the abdominal muscles may be divided. After the transversalis fascia also has been passed, the fatty capsule of the kidney is exposed throughout a sufficient extent. This capsule is divided and the kidney is removed from its bed by blunt dissection with the fingers until the organ, completely freed at all points with the exception of its

FIG. 265.—Incision and posture for exposure of the right kidney.

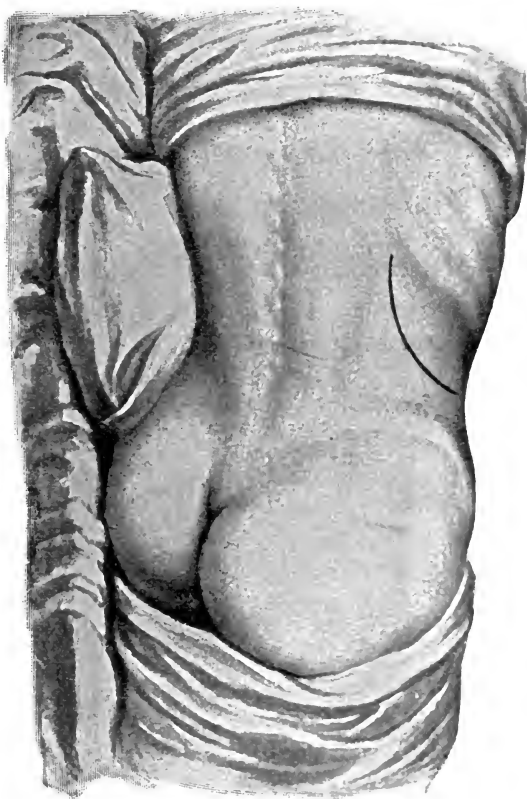


Plate 37.—Nephrotomy.

Right hydronephrotic kidney exposed through a lumbar incision and brought out of the wound. The large vessels (*A*) can be seen passing over the anterior wall of the dilated renal pelvis (*P*). Below, the beginning of the ureter is visible. The kidney has been incised through its free border, and the pelvis of the kidney has thus been opened. In the background of the wound the peritoneum (*Pp*) is visible.

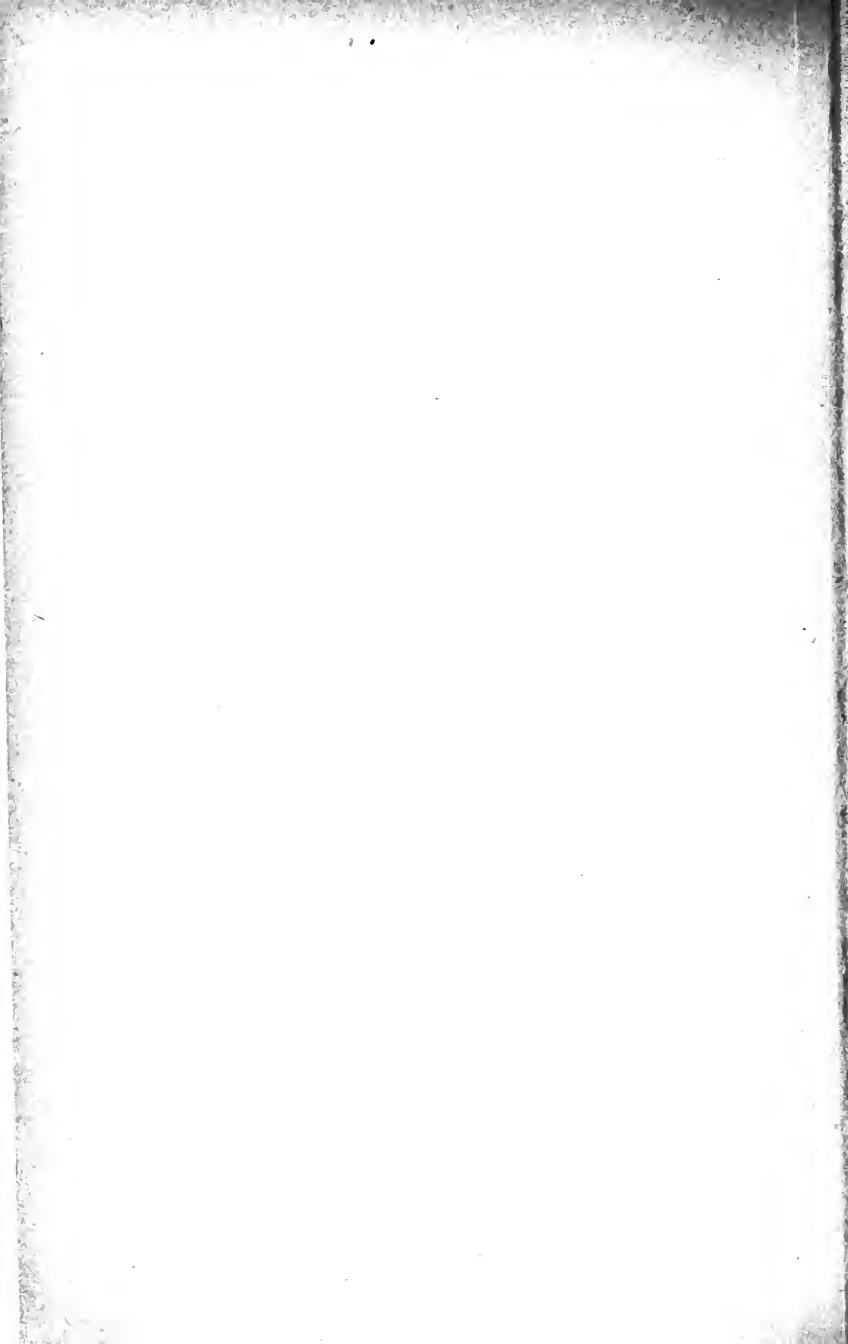
hilus, can be brought by traction to the level of the wound.

For exploration of the pelvis of the kidney, for the removal of stones from the pelvis, etc., the kidney is opened from its convex border (Plate 37). An incision is made upon the convexity, through the renal parenchyma, down to the pelvis of the kidney, large enough to permit the introduction of the index-finger, with which the pelvis is examined. If necessary, this incision may be extended toward the poles of the organ to a maximum degree until the kidney can be separated in two halves. This procedure is carried out with digital compression of the large vessels at the hilus of the kidney. If the conditions are such that primary union can take place, the wound in the kidney is closed by deep and superficial interrupted catgut sutures, the organ dropped into place, and the cutaneous wound closed, except for a small opening for a drainage-tube. Provisional suture of the wound in the kidney for the control of hemorrhage may also be undertaken if, in immediate conjunction with an exploratory incision, the removal of the entire organ is determined upon. In extirpation of the kidney the large vessels at its hilus must be exposed and carefully ligated. If possible, the kidney is drawn forward and the artery and the vein are isolated at the hilus. If this is not possible, the operator grasps the hilus of the organ with the thumb and index-finger of the left hand, and with the guidance of this hand applies a clamp-forceps around the entire pedicle. The pedicle is divided beyond the grasp of the forceps with scissors and ligated *en masse* upon the proxi-



P

P



mal side. The large vessels exposed in the transverse incision are further isolated and ligated separately.

The large wound-cavity is closed after perfect control of hemorrhage, and is drained, and the wound is closed by sutures in tiers (muscles, fascia, skin).

To effect *operative fixation of a movable kidney* (nephropexy, nephrorrhaphy) the organ is exposed in the usual manner, the sutures (ten or twelve) for the fixation of the organ being passed deeply through its parenchyma and placed in the upper angle of the cutaneous incision on either side and tied. In this manner the kidney is suitably located and fastened. The method of retroperitoneal exposure of the kidney described affords as a rule sufficient access to the organ. In the presence, however, of large diffusely adherent tumors of the kidney, or in the case of adipose individuals, it may be necessary, to afford greater accessibility, to make from the middle of the lumbar incision a transverse incision passing toward the umbilicus.

Bardenheuer recommends the so-called trap-door incision. From the upper and lower extremities of the vertical longitudinal incision passing from the costal arch to the middle of the crest of the ilium transverse incisions are made along the rib and the iliac crest. Bardenheuer makes three forms of trap-door incision, an anterior, \sqsubset , a posterior, \sqsupset , and a two-sided one, \sqcap .

In contradistinction from the retroperitoneal method described is the transperitoneal method for exposing the kidney. In this latter operation the abdominal cavity is opened in the usual manner in the linea alba, the peritoneum over the kidney is divided, and the organ is enucleated out of its bed. The retroperitoneal method has, on the other hand, the advantage of permitting, in conjunction with an exploratory procedure, of the establishment of a renal fistula, of the drainage of an abscess of the kidney under favorable conditions, as well as total removal of the entire organ.

Operations on the Ureters.—The ureter passes from the kidney on either side in the subserous space just behind

the peritoneum to the fundus of the bladder. In its upper portion it lies upon the psoas muscle, crossing at its entrance into the pelvis the point of division of the common iliac artery, and entering the pelvis in a direction forward and inward to reach the base of the bladder. Most commonly injuries of the ureter in the course of surgical procedures furnish the indication for operations upon this structure; less commonly impaction of stones in the ureter, occlusion of the lower extremity of the ureter by a neoplasm, or kinking of the ureter in cases of hydronephrosis.

Of operations there have been performed: linear opening of the ureter for delivery of a stone, with subsequent suture of the incision (*ureterolithotomy*); the displacement of a stone present along the ureter into the pelvis of the kidney; and, finally, digital attrition of soft stones without opening the ureter. In the presence of division of the ureter, restoration of the lumen of the tube by suture of the stumps or grafting of the central stump of the ureter into the rectum or some other viscus may be undertaken to effect closure of ureteral fistulæ. With this end in view the ureter has been united with the bowel (*uretero-enterostomy*), with the ureter of the opposite side (*uretero-ureterostomy*), and with a new portion of the bladder (*ureteroneocystostomy*). Anastomosis of the ureter with the bowel has also been undertaken for the correction of ectopy of the bladder (Roux, Simon). Circular union of the transversely or obliquely divided stumps of the ureter has the disadvantage, in view of the narrow caliber of the ureter, of being followed by such contraction of the cicatrix as to result in narrowing of the lumen of the tube. For this reason the invagination-suture of Van Hook is to be preferred. The free end of the peripheral stump is closed by a ligature, 2.5 mm. below which a longitudinal incision is made through the thickness of the wall of the (peripheral) stump. The central stump is caught with a catgut suture, which, with a thread armed with a needle, is passed through the longitudinal incision, the needle being further passed through the opposite wall of the

stump. By gentle traction on the suture the central stump of the ureter is drawn through the slit in the peripheral portion, and fastened in position by knotting the thread in this situation. A few additional sutures on the outer side insure contiguity of the stumps (Fig. 266).

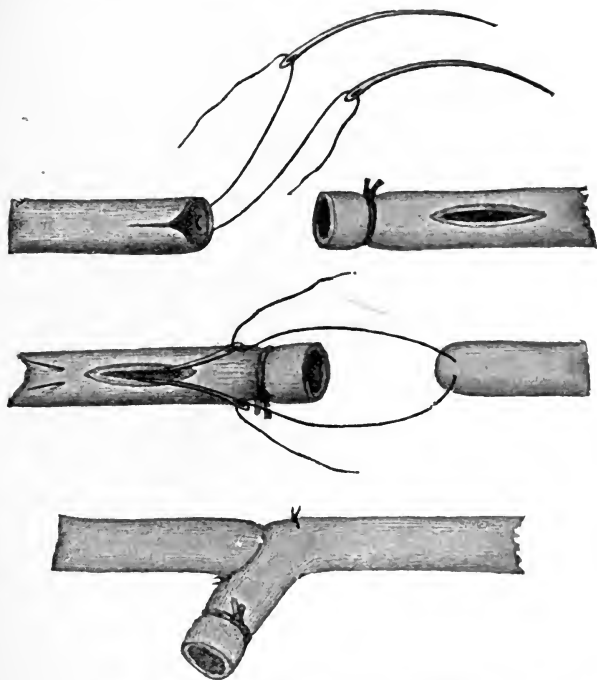


FIG. 266.—Invagination-suture of the stumps of the divided ureter.

In the practice of implantation of the ureter according to Büdinger and Witzel, the formation of a mural canal in which the ureter is contained (oblique fistula, see p. 316) most nearly imitates the natural mode of entrance of the ureter. The divided ureter is implanted in the wall of the selected organ in the same manner as is the

rubber tube in Witzel's operation of gastrostomy, and is fixed in position by suture. For exposure of the upper portions of the ureter the lumbar incision, as for nephrectomy, may be made advantageously. The pelvic portion of the ureter in the male can best be rendered accessible through the transperitoneal route. The pelvis is elevated, and the abdominal cavity is opened by an incision passing from the symphysis to the umbilicus. The ureter, where it crosses the large vessels, can be seen glimmering through the serosa, and, after division of the peritoneum of the pelvic wall, it can be freed and followed deeply into the pelvis. The lowermost portion of the ureter, a point of election for impacted calculi, can be exposed in the female from the vaginal vault, and in the male by the sacral route (p. 330) or with the aid of a prerectal flap-incision (Plate 38).

Operation for Ectopy of the Bladder.—Attempts have been made upon various lines to treat, by operation, ectopy of the bladder, which is invariably associated with separation of the symphysis and epispadias. Those methods will be mentioned first that aim at restoration of the cavity of the bladder. Trendelenburg severs the sacro-iliac symphysis on each side through an open wound. With lateral compression the stumps of the pubic symphysis can be brought in apposition. The child is kept for several weeks in a special apparatus, by means of which the pubic symphysis is held closed. The margins of the defect are then freely freshened and are united by linear suture, in order to effect closure of the defect in the bladder.

The restoration of the deficient anterior wall of the bladder by means of a plastic flap has been recommended especially by Thiersch. The epispadias is, in the first place, operated upon. Then the defect in the bladder is closed, an upper flap being reflected over the margin of the freshened defect, and sutured in place in such a manner that its epidermic surface is directed toward the cavity of the bladder. Two lateral bridge-flaps are prepared, dissected from the subjacent tissues, and when they are in a state of granulation are cut free at one extremity,

reflected over the first flap, and united over this in the middle line. Czerny detaches the mucous membrane of the defect from the subjacent tissues for a sufficient extent for the margins to be united. The bladder thus formed is covered by two lateral bridge-flaps. At a later stage the divided urethra and the neck of the bladder are freshened and sutured.

The formation of a continent sphincter can scarcely ever be secured to a satisfactory degree. A number of methods of operation dispense with the establishment of a vesical cavity and are directed to conveying the urine into some other cavity of the body or elsewhere, from which point it can more readily be expelled. Sonnenburg practises extirpation of the bladder and permits the ureter to empty into the groove in the penis. Roux, Simon, and others implant the ureters in the rectum. Maydl removes the bladder with the exception of the trigonal portion, which is permitted to remain in connection with the ureters. This portion of the bladder is sutured into the opened sigmoid flexure.

Maydl's operation appears to be the most valuable of the derivation methods. It secures continence and retains the bladder with the sphincter apparatus in connection with the orifices of the ureters, and in this way is afforded sufficient protection against infection of the kidneys. The upper boundary of the defect is first surrounded by an incision, which is deepened down to the peritoneal cavity. A similar incision is made around the lower boundary, with conservation of the ureters, until the detached bladder remains connected only with the two ureters. The vesical flaps are cut in such a manner that the trigonal portion alone is preserved in the form of a transverse ellipse. The sigmoid flexure is brought forward and opened by a longitudinal incision. The vesical flap is implanted in such a manner that the lower border of the ellipse is united with the right, and the upper extremity with the left, lip of the wound in the bowel. The suture is applied in two tiers.

Operations upon the Sexual Organs.—Prostatotomy.—Opening of the prostate through an incision in the perineum is indicated in the presence of abscesses and for the curetting of tuberculous masses in the gland. After the root of the penis and the superficial transverse perineal muscle are exposed by an incision through the perineum and the connections between the sphincter ani



FIG. 267.—Prostatotomy: mode of making the prerectal incision.

and bulbocavernosus muscles are divided transversely, the anterior wall of the rectum can be separated by blunt dissection from the prostate gland and reflected toward the sacrum. Between the triangular ligament of the urethra and the rectum thus displaced the slightly convex posterior aspect of the prostate lies exposed throughout its entire extent (Fig. 268).

The performance of prostatotomy in the presence of an abscess is performed as follows: the patient occupies the same position as in the operation for stone, and an English catheter of large caliber is introduced into the urethra. The operator sits in front of the patient and guides the

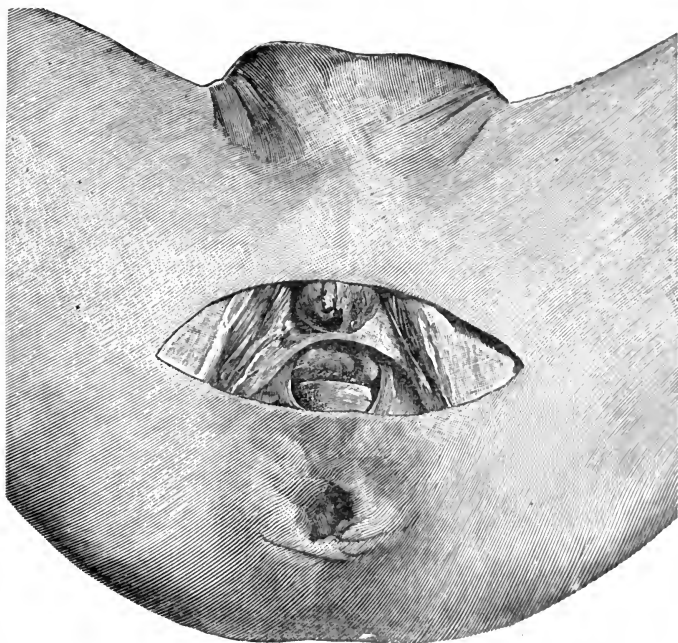


FIG. 268.—Prostatotomy: appearance of the wound after separation of the rectum; in the upper part the bulb of the urethra and the ischio-cavernosus muscle are visible; in the lower, bounded by the arms of the levator ani muscle, the prostate and the anterior wall of the rectum.

knife with his right hand, while the index-finger of the left hand is introduced into the rectum, in order that in the progress of the deep dissection the anterior wall of the rectum shall be avoided (Fig. 267). A curved incision 4 or 5 cm. long is made through the prerectal

Plate 38.—Exposure of the Prostate Gland, the Seminal Vesicles, etc., by Means of a Prerectal Flap Incision by the Method of O. Zuckerkandl.

Above, the wound is bounded by the bulb of the urethra (*B*), with the bulbocavernosus muscle, and by the cavernous bodies of the penis with the ischiocavernosus muscle (*Ic*). Between the bulb and the prostate a portion of the membranous part of the urethra (*Pm*) is visible. The detachment of the rectum has been effected in maximum degree. The prostate gland (*P*), the seminal vesicles (*Vs*), the extraperitoneal portion of the posterior wall of the bladder (*B*), and, finally, at the bottom of the wound, the line of reflection of the peritoneum (*Bf*) from the bladder upon the rectum (*R*) are exposed to view.

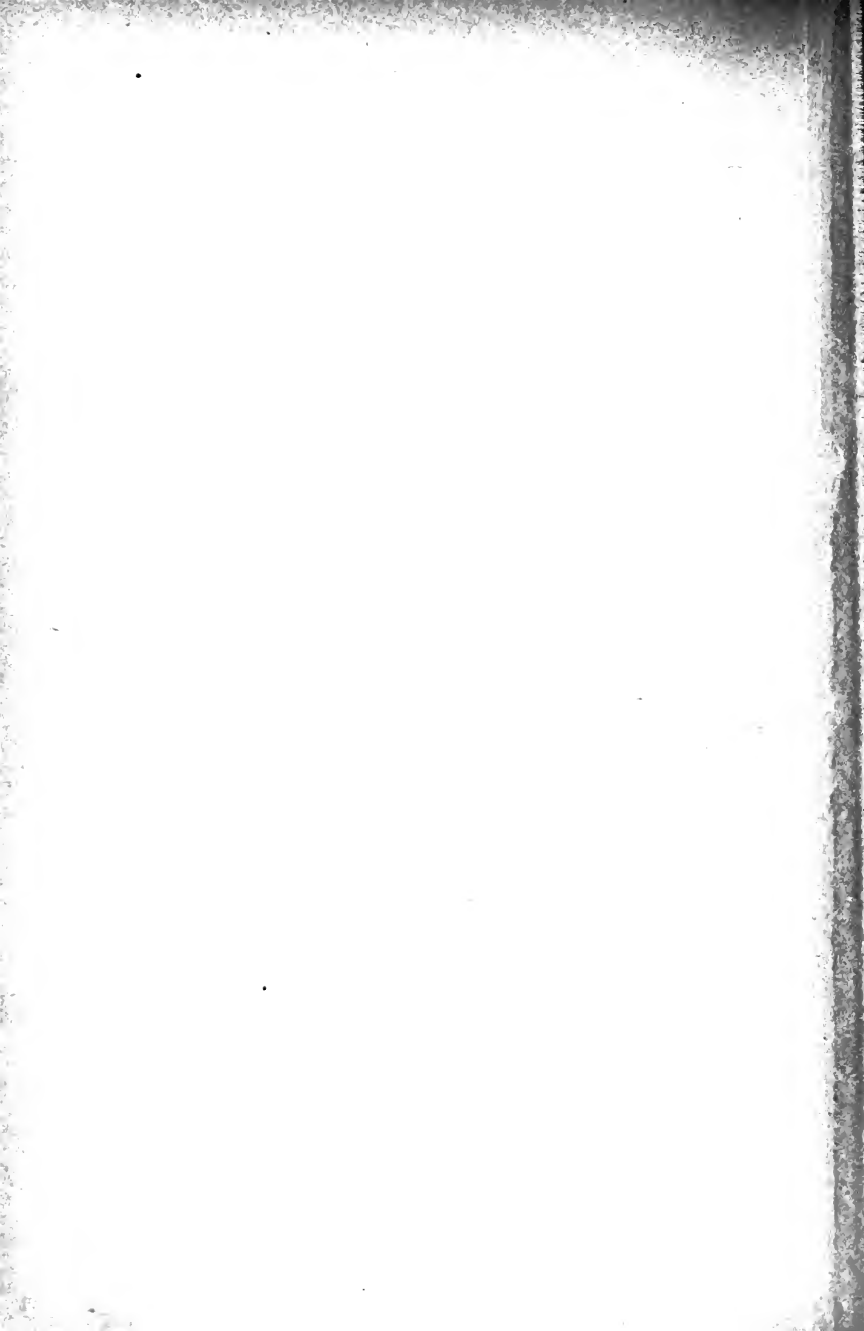
tissues. After division of the skin and the subcutaneous connective tissue, the perineal septum, the connection between the sphincter ani and the bulbocavernosus muscle, is divided transversely, and blunt dissection is made between the rectum and the urethra upward toward the prostate. When the lower pole of this organ or a portion of its posterior wall is exposed in the wound, a grooved director or a pair of forceps with closed blades is introduced into the fluctuating portion, when the pus escapes through the wound. The opening is now suitably enlarged, and the abscess-cavity is tamponed. If a communication exists between the abscess-cavity and the urethra, the retention of a catheter is necessary in the after-treatment.

Extirpation of the Seminal Vesicles.—In extirpation of the seminal vesicles the perineal route just described appears the most desirable. The patient and the operator occupy the same positions as in the operation just considered. A large perineal flap-incision is made, whose posterior extremity on either side extends to the ischial tuberosities and whose anterior boundary lies in front of the rectum. The prostate gland is exposed in the manner previously described. With further blunt detachment of the rectum the lower portions of the seminal vesicles attached to the base of the prostate come into view. On continued detachment of the rectum from the bladder, the seminal vesicles and the terminal portions of

Ppt.

R.





the vasa deferentia are completely exposed, as is also the fundus of the bladder uncovered by peritoneum. Finally, the line of reflection of Douglas's fold can be brought into view in the wound (Plate 38). The altered seminal vesicles are peeled out of their surroundings, dissected from the fundus of the bladder, and removed. At the same time morbid collections in the prostate gland can be excised.

Excision of the Prostate; Prostatectomy.—In cases of hypertrophy of the prostate gland removal of the enlarged middle and lateral lobes has been recommended for the relief of the difficulty in urination, and has been practised by numerous surgeons with varying success. The question whether cure is effected by removal of the prostatic obstruction is not as yet decided. At any rate, advanced cases in which secondary changes in the wall of the bladder and of the upper urinary passages have taken place are not adapted to the operation.

The *enlarged middle lobe* of the prostate, which often attains the size of a walnut and more, may be extirpated through the suprapubic incision into the bladder (M. C. Gill). The bladder is opened above the symphysis pubis in the usual manner, and the prominent tumor is removed with the Paquelin cautery, the galvanocautic loop, or with curved scissors. The base of the wound is cauterized for the control of hemorrhage, and, if necessary, the bladder is tamponed.

The *enlarged lateral lobes* of the prostate can be only partially removed or subjected to wedge-shaped excision, care being taken to avoid opening the urethra. In the performance of partial resection adequate exposure of the body of the prostate is essential. The gland is exposed either with the aid of the perineal prerectal incision or through a sacral incision. The details of the first method are given on page 376. The sacral method of exposing the prostate has been recommended by Dittel (*lateral prostatectomy*). In this mode of procedure an incision is made in the folds of the anus, the rectum is displaced

laterally, and in this way the posterior surface of the prostate is brought into view. The patient occupies the right lateral decubitus, and an English catheter is introduced into the urethra. The incision begins at the apex of the coccyx, passes in the middle line to the posterior margin of the anus, which it surrounds upon the right side, and terminates in the perineal raphe in front of the anus. The operator gains entrance into the ischiorectal fossa, and separates the rectum by blunt dissection from the prostate, so that the right lateral lobe of the latter and, if the dissection be continued, the entire posterior aspect, are exposed to view. Wedge-shaped portions of the gland are excised on either side. Dittel recommends that so much of the gland be removed that only sufficient remains to surround the urethra. The removal of the coccyx is calculated to enlarge the field of operation.

Resection and Extirpation of the Vas Deferens.—Resection of the vas deferens in its continuity has been recommended recently in the treatment of hypertrophy of the prostate gland, and has been performed in numerous cases. The vas deferens is palpable through the skin as a round, firm strand, and it may thus be separated from the remaining structures of the spermatic cord. The cutaneous incision for the isolation of the vas deferens, 3 or 4 cm. long, may be made either in front of the external inguinal ring or at the neck of the scrotum. The structures forming the spermatic cord are forced out of the wound, the vas deferens is isolated by touch, and a portion from 2 to 4 cm. long is excised between two ligatures with scissors. Removal of the vas deferens in connection with the testicle becomes necessary when in the presence of tuberculosis of the epididymis the vas deferens also is involved in the disease. Under these conditions the incision for exposure of the testicle, which passes longitudinally over the scrotum, is extended upward and outward over the inguinal canal. Throughout the range of the incision the skin and the anterior boundary of the inguinal canal are divided so that the vas deferens is exposed in its course

through this canal, and is thus rendered accessible to surgical removal. The pelvic portion of the vas deferens would be accessible by this means only after extended detachment of the peritoneum, entailing injury of disproportionate degree. This portion of the duct is therefore to be reached by the perineal route or with the aid of an incision such as Dittel has recommended in the performance of lateral prostatectomy.

Büngner recommended *divulsion of the vas deferens*. The duct is isolated and exposed throughout a considerable extent by gradually increased traction. With careful manipulation of this kind four-fifths of the entire duct may be removed.

Extirpation of the Testicle: Castration.—The indications for this operation consist in the presence of neoplasms of the testicle and tuberculosis of the epididymis. Another indication for castration is afforded by hypertrophy of the prostate. The cutaneous incision is always made longitudinally over the greatest convexity of the tumor. In making this incision the operator grasps the scrotum with his left hand in such a manner that the overlying skin is made tense. If the skin is involved in the disease-process throughout a circumscribed area (from extension of a neoplasm or the formation of a tuberculous fistula), the diseased structure is included between the incisions and is removed in conjunction with the testicle. The incisions are made through the skin and the dartos down to the tunica vaginalis, and the testicle, with its coverings, is freed from its bed by blunt dissection, so that it remains in connection with the body only through the intermediation of the spermatic cord. By traction on the cord its constituent structures are more clearly brought into view. The vas deferens is isolated and ligated. The remaining structures of the spermatic cord are ligated *en masse* in two or three segments. The cord is then divided transversely on the distal side of the ligatures, which are cut short. The stump of the cord retracts into the depth of the wound, and the cutaneous wound is closed by suture.

Operation for Varicocele.—When varicocele gives rise to persistent symptoms, operative intervention is indicated. At the present time excision of the dilated veins of the spermatic cord is practised almost exclusively. Digital compression or the application of an elastic ligature around the scrotum may facilitate the operation. A longitudinal incision is made through the skin of the scrotum. This is deepened, and the group of dilated veins is exposed. The individual strands are isolated, ligated above and below, and divided between the ligatures. Some veins are left undisturbed in the spermatic cord. The cutaneous wound is completely sutured. A modification of the procedure exposes the plexus not in the scrotum, but over the external inguinal ring. To provide greater support in the presence of varicocele, resection of the scrotum has been practised. To meet the same indication, Köhler recommends, after resection of the veins, transverse suture of the longitudinal incision in the scrotum.

Operation for Hydrocele.—Hydrocele is treated in a palliative way by simple puncture and in a radical way by laying it open by an incision. Puncture of a hydrocele is made in accordance with the rules that govern the making of punctures in general. The operator must, however, be assured of the position of the testicle, in order to avoid injuring this organ in introducing the trocar. The scrotum is grasped firmly and made tense with the supinated left hand. The introduction of the trocar is made upward through the anterior wall close to the fundus of the scrotum at a point where no vein is visible through the skin. At first the fluid is expelled in a continuous stream. Later the escape must be facilitated by alteration in the position of the cannula and by kneading movements of the scrotum. The injection through the cannula of from 5 to 10 gm. of Lugol's solution, in conjunction with the puncture, is a favorite mode of radical operation for hydrocele. The procedure, however, is extremely painful, and with regard to the certainty of the result stands behind radical incision.

Radical Incision by the Method of Volkmann.—The scrotum is grasped firmly and made tense with the left hand and an incision is made longitudinally over the greatest convexity of the tumor almost up to the fundus. With careful dissection the incision is carried down to the tunica vaginalis, which is divided in the direction and throughout the extent of the cutaneous incision. After the fluid has escaped, the tunica vaginalis is united to the skin by a row of sutures and a strip of gauze is introduced into the cavity that remains. The process of healing often occupies a considerable period of time.

Radical Operation by the Method of Bergmann.—Radical operation by the method of Bergmann is followed by recovery within a short time, by reason of the fact that the wound-conditions render possible union by primary intention. A cutaneous incision is made in the manner just described. Before the sac of the hydrocele is opened, an endeavor is made to free it from the overlying skin throughout a considerable extent. After this has been adequately effected the sac is opened as in the operation of Volkmann. After the fluid has escaped the operator grasps the margins of the incision through the tunica vaginalis and separates this from the testicle on either side, almost to the point of reflection. After this detachment has been thoroughly effected the freed parietal layer of the tunica vaginalis is excised. The margins of the incision in the skin are accurately approximated by suture over the testicle, which is dropped back into the wound.

Less radical is the procedure of Winkelmann, which is a modification of the method just described. The sac of the hydrocele is opened by an incision 3 or 4 cm. long. After escape of the fluid the testicle is forced through the incision made in the vaginal tunic, and this is closed by suture to such a degree that the return of the testicle into the tunic is rendered impossible. The cutaneous wound is closed over the folded serous sac and the testicle. The serous surface of the proper vaginal tunic, directed out-

ward, faces the subcutaneous connective tissue, to which it may become adherent.

CIRCUMCISION.

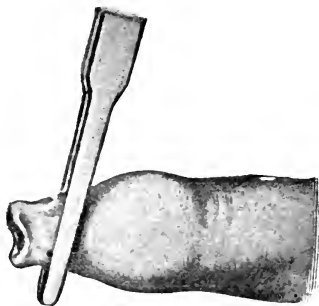


FIG. 269.—The prepuce is clamped for removal.

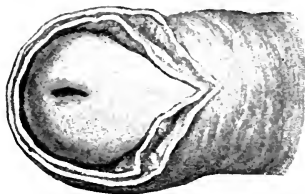


FIG. 270.—The foreskin has been removed by a circular incision and incised on its dorsal aspect. The two layers of the prepuce are visible in the transverse incision.

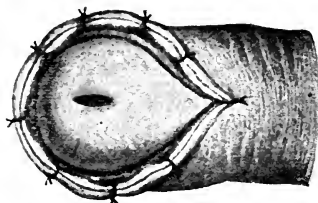


FIG. 271.—Inner and outer layers of the prepuce united by suture.

Operation for Phimosis.—Operations for phimosis include surgical procedures of various kinds by means of which congenital or acquired narrowing of the prepuce is removed. In performing the operation either the prepuce is divided longitudinally from its orifice to the glans (*incision*) or the entire prepuce is removed (*circumcision*). By the first of these methods the incision is made in the middle line of the dorsal surface, a grooved director, with

its concavity directed upward, being introduced into the orifice between the prepuce and the glans. The two layers of the prepuce are divided over the director almost up to the corona glandis with a single stroke of the scissors. After the division has been effected the prepuce must be readily retractable over the glans. Throughout the extent of the wound the mucous membrane of the prepuce is united with the skin by means of a series of interrupted sutures or by a continuous suture.

Circumcision may be effected in various ways. The prepuce is clamped in front of the glans and removed with scissors in front of the clamp (Fig. 269). By addition of the dorsal incision the opening in the preputial sac can be enlarged to any desired extent (Fig. 270). The margins of the skin and the inner layer of the prepuce are united by suture (Fig. 271). In another method of circumcision the usual dorsal incision is first made, after which portions of the prepuce on either side of the incision are removed with scissors close to the point of reflection on the glans. Throughout the entire extent of the wound the skin is united with the inner layer of the prepuce.

Operation for Shortened Frenum.—Congenital shortness of the frenum, with a normal caliber of the prepuce, is attended with numerous discomforts (pain in coitus, frequent laceration, hemorrhage). Simple transverse division of the band is not to be recommended on account of the hemorrhage that follows. Division with the Paquelin cautery secures immunity from the hemorrhage, but a considerable time is occupied in the healing of the wound. Functionally good results, with the possibility of securing union by primary intention, are yielded by the following minor plastic operation :

The frenum is divided with a single stroke of the scissors to such a depth that the prepuce can be retracted to a maximum degree without tension. The small wound thus made is united at a right angle to the direction of the incision (Figs. 272 and 273).

OPERATION FOR SHORTENED FRENUM.



FIG. 272.

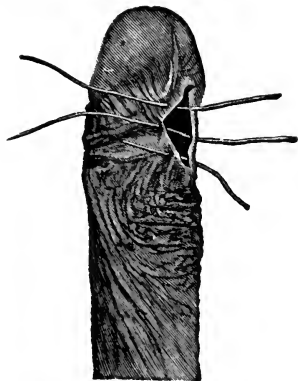


FIG. 273.

FIG. 272.—Transverse division of the frenum.

FIG. 273.—Union at right angles to the direction of the division.

Amputation of the Penis.—Carcinomata constitute the most frequent indication for amputation of the penis. In rare cases gangrene, phagedenic chancre, and stricture of the urethra (Dittel) have necessitated removal of the penis. This may be practised through the pendulous portion at a selected level by means of a circular incision. Under certain conditions the deeper portions of the member, the roots of the cavernous bodies, must be removed by operation. In all cases, after ablation of the parts, the urethra must be suitably situated and fixed in the wound.

In amputating the penis through the pendulous portion digital compression is exercised, while a circular incision is made transversely. The skin is retracted after division, when the operator divides the cavernous bodies transversely with an amputation-knife, cutting from the dorsal aspect toward the urethra. When the urethra is reached, it is dissected free for a short distance toward the periphery and is divided transversely 2 cm. in advance of the line of incision through the cavernous bodies (Fig. 274). The urethra is snipped through its inferior surface

AMPUTATION OF THE PENIS.

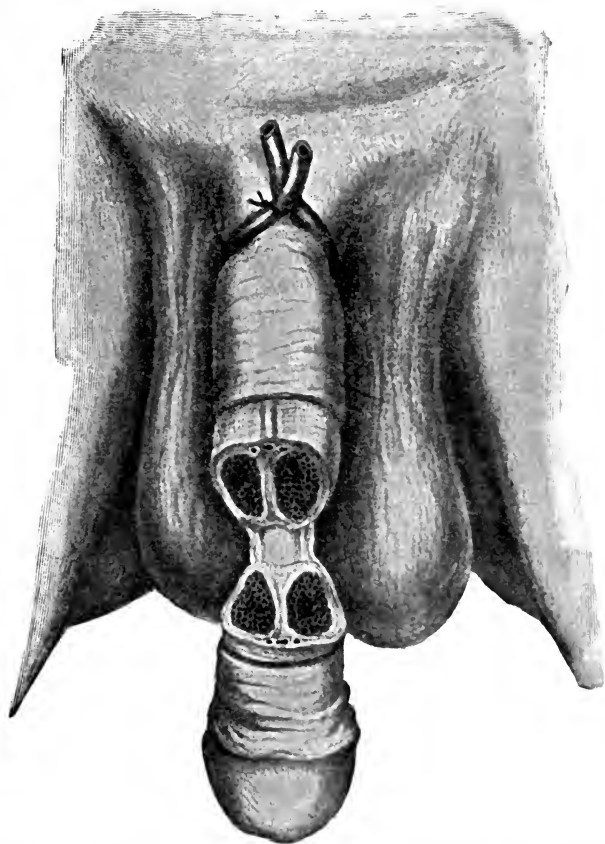


FIG. 274.—The penis is surrounded with an elastic ligature, the skin is divided by a circular incision, the cavernous bodies are cut through, and the stump of the penis is still attached by the urethra, which, for a short distance forward, is dissected free.

with a single stroke of the scissors, spread upon the wound, and united by its free border with the margin of the skin by means of a series of sutures (Fig. 275).

AMPUTATION OF THE PENIS.

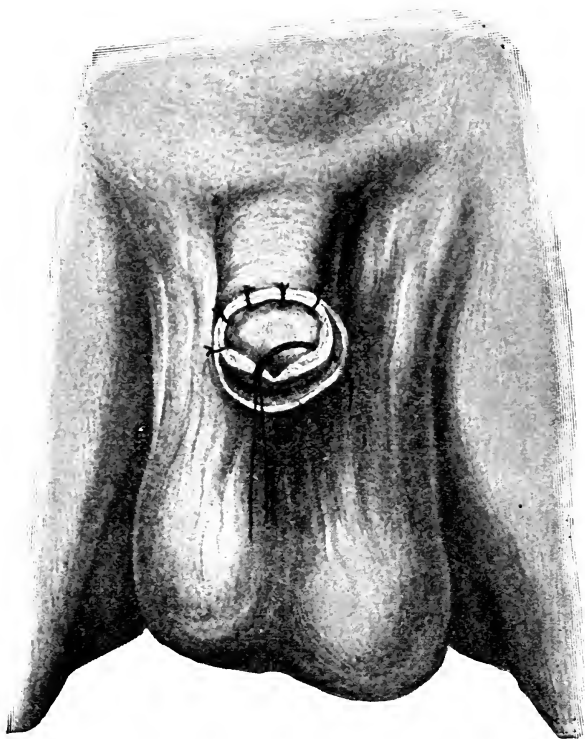


FIG. 275.—The amputation is completed; the urethra, incised on its under surface, is stretched over the cut surface of the cavernous bodies, and its margins are appropriately united with the skin.

In amputating the penis in conjunction with its perineal connections the scrotum is divided in a sagittal direction. In the gaping wound the roots of the cavernous

bodies, with their attachments to the pubic bones, are readily exposed. The urethra is divided transversely through healthy structure, snipped on its lower surface, and sutured in the posterior angle of the wound (*perineal urethrostomy*).

The cavernous bodies of the penis are detached and reflected upward in conjunction with the peripheral portion of the urethra. If the detachment has been extended to the pendulous portion, the penis is, after circular incision of the skin, divided transversely at its scrotal attachment and removed. The scrotal wound is closed by suture up to the newly established orifice of the urethra.

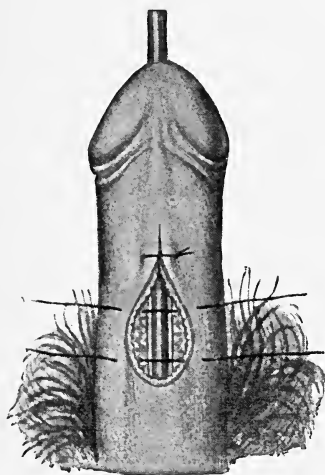


FIG. 276.—Urethral fistula: elliptic freshening; suture.

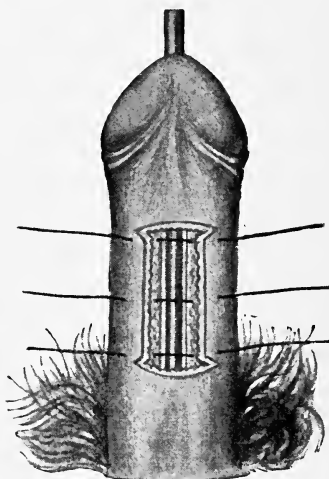


FIG. 277.—Urethral fistula freshening, with the formation of lateral flaps; suture.

Operation for Urethral Fistula.—So long as the fistulous passage is not covered over by skin, spontaneous cure may be effected by local applications conjoined with dilatation of the urethra. Under the reverse conditions, or if the mucous membrane of the urethra is adherent to the skin, freshening of the margins of the wound, with suture, be-

comes necessary to effect a cure. If the fistula be small, an elliptic area is freshened and the defect is closed by transverse deep and superficial sutures (Fig. 276). In freshening an oval area the formation of lateral flaps is advisable. These flaps are formed by means of incisions made on either side close to the upper and lower extremities of the oval area. The flaps are detached from the subjacent structures, and, after the introduction of buried sutures, are brought together and united over the defect (Fig. 277). Further, it is a useful procedure, after freshening the margins of the fistula, to separate the skin from the mucous membrane throughout the extent of the defect by means of horizontal incisions, so that the margins of the mucous membrane can be approximated without tension. The opening in the mucous membrane is united by means of catgut sutures, and finally the wound in the external integument is closed. In the presence of an extensive defect in the urethra a tegumentary flap taken from the penis is brought over the freshened defect in such a way that its cutaneous aspect is turned toward the lumen of the urethra. The second step consists in union of the wound in the skin.

Operation for Hypospadias.—The Hacker-Beck method was originally devised for the treatment of hypospadias of the glans. The urethra, together with its cavernous bodies, is dissected free for the desired distance. The second step of the operation consists in the formation of an artificial canal in the imperforate glans, terminating at the extremity at a point corresponding to the normal orifice of the urethra. The distensible urethra, dissected free, is drawn through the canal of the glans, and its extremity is sutured to the end of the glans.

Penile and perineal hypospadias requires a more extensive plastic operation. According to Duplay, the operation is performed in such a manner that at the first sitting a possibility of straightening the part is established by means of a transverse incision between the glans and

the orifice of the urethra. The transverse wound is united in a longitudinal direction. After cicatrization of this wound the formation of the urethra is proceeded with. At a distance of 6 or 7 mm. from the middle line a longitudinal incision is made on each side on the under surface of the penis, from the glans to the orifice of the urethra. The inner lip of this wound on either side is detached for a sufficient distance to permit union of the flaps, with the epidermic aspect directed inward, over a tube in the middle line. The outer lips of the longitudinal wounds are likewise dissected sufficiently and are sutured in the median line over the already formed urethra. After a canal lined with epidermis is in this way formed upon the lower side of the penis, closure of the urethral orifice yet remains to be effected, and this may be freshened throughout a considerable extent and be sutured. A canal had previously been formed in the glans and had been united with the newly formed urethral canal by freshening and suture.

The urethra of the glans is best formed in such a manner that an incision is made deeply into the tissues on the under side of the glans to the right and the left of the canal to be formed, and somewhat convergent. The middle portion is depressed, following which, after the introduction of a tube, the two lateral portions are united in the middle line. As in simple operations for fistula, also here, success is often prevented by evacuation of the urine and by erection of the penis, which tear out the sutures. Numerous corrections and repeated operations are, therefore, required before the desired result is brought about. Often the endurance of both physician and patient is put to a severe test. The evacuation of urine exerts an injurious influence, whether the patient is permitted to urinate spontaneously or a retention-catheter is introduced. In the performance of plastic operations of considerable extent upon the penis, the temporary establishment of a vesical fistula through the abdominal wall is for this reason to be recommended.

Operations for Hernia.—Bloody operations for hernia are undertaken for the purpose of either releasing an existing strangulation or removing a free or adherent hernia (*radical operation*). The first form of operation (*herniotomy*) consists in division of the coverings of the hernia, opening of the hernial sac, and division of the constricting ring. The further operative steps which may be indicated (reposition of the intestine, formation of a preternatural anus, resection of the bowel) will be governed by the conditions present in the individual case. The cutaneous incision is made in the longitudinal axis of the hernial tumor; in the presence of inguinal hernia in such a manner that the inguinal canal, as well as both inguinal rings, is included within its range. In the presence of femoral hernia the vertical incision passes over the greatest convexity of the hernial tumor. By careful dissection, layer by layer, after division of the subcutaneous connective tissue and the so-called proper fascia of the hernia, the hernial sac is reached. This presents a dull appearance, is in places the seat of small masses of fat, and is often so delicate that the hernial fluid can be seen through it. In the presence of inguinal hernia it will be necessary to divide in the upper portion of the hernial tumor the anterior wall of the inguinal canal, constituted by the aponeurosis of the external oblique muscle and fibers of the internal oblique and transversalis muscles, before the actual coverings of the hernial swelling are reached. The sac of the hernia is incised in the direction of the cutaneous incision, and, after the hernial fluid has been permitted to escape, the removal of the constriction is undertaken. In the presence of an inguinal hernia it will be possible always to expose the constricting ring by division of the anterior wall of the inguinal wall throughout its entire extent (Fig. 278). This is done carefully from without inward until all tension has disappeared.

In the case of femoral hernia division of the constricting band is effected from the cavity of the hernia by means of a blunt-pointed knife, or herniotome, under

guidance of the finger, and always directed inward. The sharp margin of Gimbernat's ligament is incised and the constriction is thus removed. After the division of the constricting band has been effected the involved loop of



FIG. 278.—Inguinal hernia: the hernial sac is opened; the outer portion of the constricting ring is exposed.

intestine is brought forward so that the point of strangulation, as well as the proximal intestine, may be scrutinized. If the serous layer is smooth and glistening, the loop of bowel is restored to the abdominal cavity. To effect reposition the loop of intestine is gently compressed, so that any contents that may be

Plate 39.—Bassini's Operation for Inguinal Hernia.

I. Exposure of the aponeurosis of the external oblique muscle and the external inguinal ring.

II. The aponeurosis of the external oblique muscle is divided, as well as the internal oblique and transversalis muscles; the spermatic cord is retracted and at the bottom of the wound upon the peritoneum the epigastric vessels can be seen; the layer of tissue with the sharply defined border is the transversalis fascia.

present may escape. By means of pushing movements with the fingers the loop is gradually returned to the abdominal cavity through the hernial opening. During the process of reposition the hernial sac is held tense. To convince one's self that the bowel has been actually replaced in the abdominal cavity, it is recommended after reposition has been effected that a finger be introduced through the hernial ring into the abdominal cavity and be swept around the internal opening of the hernial canal. In this way defective reposition or unreal reduction will be avoided.

Prolapsed omentum is either simply replaced, or, if thickened, is ligated in segments and removed. If the contents of the hernia are adherent to the inner surface of the hernial sac (*adherent hernia*), reposition must be preceded by detachment of the adhesions.

If the serous membrane is dull at the line of strangulation, the loop of intestine is, after division of the constricting band, left in the wound. In accordance with the further course of the case the loop may be replaced after the lapse of several days or a preternatural anus may be established.

If the loop of intestine prove to be gangrenous at the time of operation, a preternatural anus is at once established, the bowel being sutured in the wound. Another procedure in the presence of gangrene of the bowel consists in primary resection and union by circular suture.

If a fecal abscess has already formed, it is opened widely and the presenting loops of intestine are secured from slipping back into the abdomen by suture.

The last step of the operation, closure of the wound, demands exact approximation of the hernial canal, with the object of preventing renewed formation of a hernia.

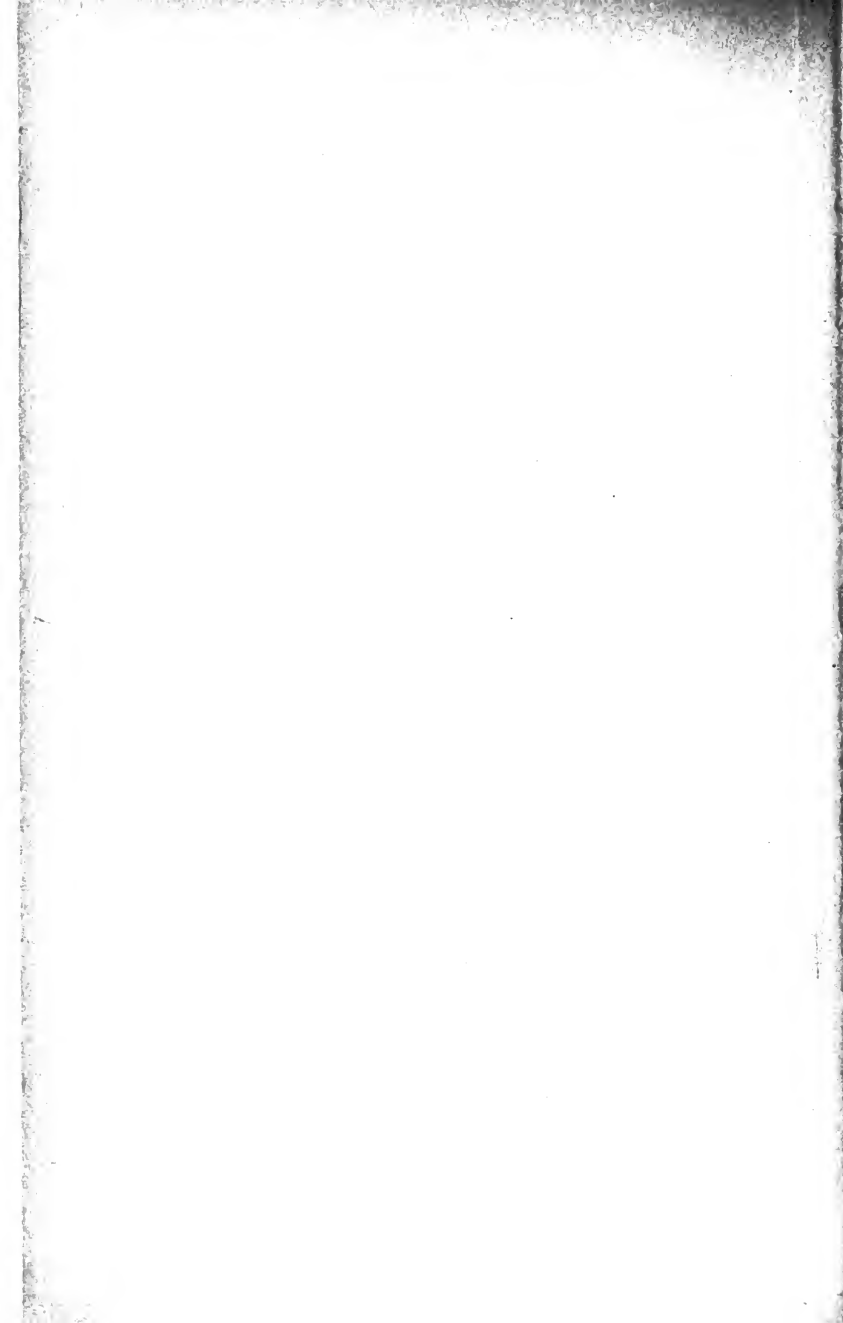
Radical Operation for Hernia.—Radical operation for hernia may be performed in conjunction with herniotomy, and is besides indicated in the presence of adherent



I.



II.



hernias or of free hernias that give rise to discomfort and cannot be retained in place with the aid of trusses.

Radical Operation for Inguinal Hernia.—The radical operation for inguinal hernia has for its object closure of the hernial canal and strengthening of the inguinal canal, which after the operation continues to serve as a channel for the spermatic cord, so that it will offer adequate resistance to the intra-abdominal pressure.

The inguinal canal comprises the interval between the internal and the external inguinal ring, and traverses the abdominal wall in an oblique direction, downward and inward. The deep opening of this canal, the internal inguinal ring, represents the entrance of the process of transversalis fascia extending into the scrotum. The external inguinal ring is formed by an opening in the aponeurosis of the external oblique muscle just above Poupart's ligament to the outer side of the tubercle of the pubic bone. The anterior wall of the inguinal canal is formed by the aponeurosis of the external oblique muscle and the fibers of the internal oblique and transversalis muscles. The posterior wall is formed mainly by the transversalis fascia, and is fortified at the level of the external inguinal ring by muscular bundles from the internal oblique and transversalis.

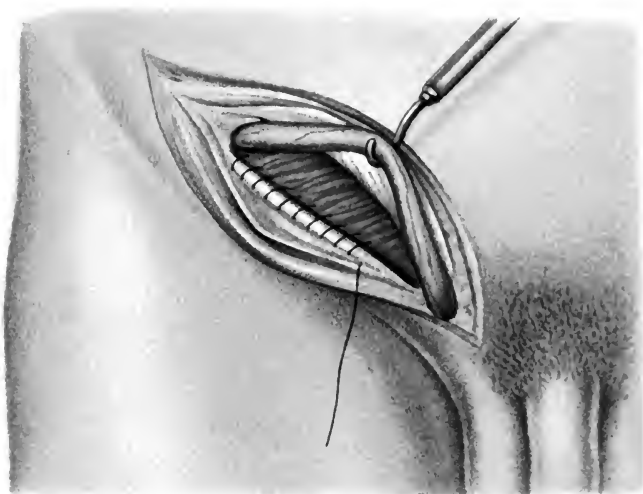
Steps of Bassini's Radical Operation for Hernia.—A cutaneous incision is made in the direction of the inguinal canal, from the neighborhood of the internal inguinal ring and passing downward beyond the external inguinal ring. After division of the skin and the subcutaneous connective tissue the aponeurosis of the external oblique muscle is divided in the direction of the cutaneous incision down to the external inguinal ring (Plate 39). After the thin muscular layer of the internal oblique and transversalis is divided in the same direction and throughout the same extent, the structures of the spermatic cord, which are adherent to the hernial sac, come into view. At the neck of the hernial sac the vas deferens, the artery and the vein of the spermatic cord are detached

Plate 40.—Bassini's Operation for Inguinal Hernia.

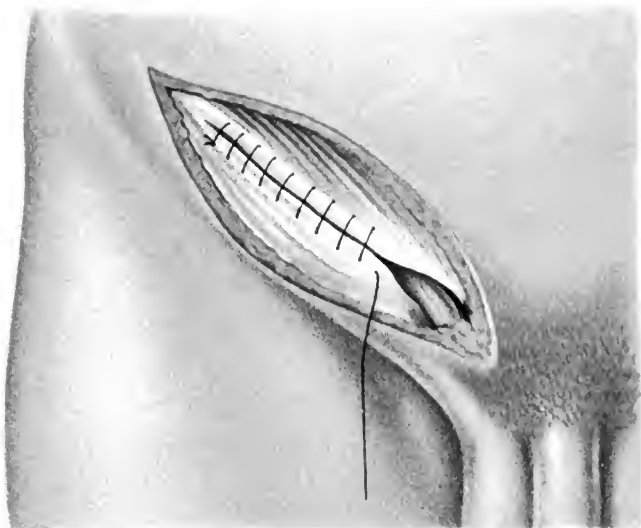
III. The muscular layer of the internal oblique and transversalis is attached by suture to the inner border of Poupart's ligament. In this way the internal inguinal ring and the posterior wall of the inguinal canal are formed anew.

IV. The aponeurosis of the external oblique is united over the spermatic cord except in the situation of the new external inguinal ring.

from the sac and they are isolated to a point beyond the hernial ring. The hernial sac is now opened at its fundus and its contents are restored to the abdominal cavity. While the hernial sac is brought forward and is twisted at its neck through an arc of 180° the operator passes a ligature around the neck of the sac and tightens it as closely as possible to the trunk. The hernial sac is divided transversely with a single stroke of the scissors at a point to the periphery of the ligature and is removed. There remains to be effected the re-establishment of a new inguinal canal with thoroughly resistant walls. If the spermatic cord has been retracted toward the median line, and if the two margins of the divided aponeurosis of the external oblique muscle have been displaced upward and downward, there will appear in the wound upon one side the groove of Poupart's ligament and upon the other side the outer border of the rectus muscle, together with the muscular plate formed by the divided internal oblique and transversalis muscles. This muscular layer is separated by blunt dissection from the subserous tissues, as well as from the aponeurosis of the external oblique, so that it is rendered sufficiently movable to be brought down to Poupart's ligament. The muscular plate named is attached to the posterior border of Poupart's ligament by sutures (Plate 40, III). The sutures on the pubic bone include also the external border of the rectus muscle. In this way a posterior muscular wall of sufficient resistance is formed, in which lies the newly created narrow internal inguinal ring. The spermatic cord is placed upon this muscular layer, and over it the aponeurosis of the external



III



IV

oblique is closed by suture except at its lower angle, which constitutes the new external inguinal ring (Plate 40, IV). The inguinal canal thus formed is, after healing has taken place, so resistant that the use of a supporting truss can be dispensed with.

In Kocher's radical operation for inguinal hernia (displacement-method) the cutaneous incision is made as in Bassini's operation, although the aponeurosis of the external oblique is not divided, but slit to the outer side of the internal inguinal ring. Through this opening a pair of forceps is introduced and passed through the inguinal canal to the external inguinal ring. The apex of the isolated hernial sac is grasped, and drawn outward through the small opening. The hernial sac is drawn so that it appears sharply bent backward at the internal inguinal ring. The portion of the sac lying within the abdominal wall is surrounded and strongly ligated. The base of the sac thus folded together is attached to the outer surface of the aponeurosis of the external oblique by means of deep sutures, and the remainder is removed.

Radical Operation for Femoral Hernia.—*The Femoral Canal.*—The interval between the internal and external femoral rings, which constitutes the path for certain varieties of hernia, is known as the femoral canal. Under normal conditions, however, a canal is not present as such. The inner orifice of the canal (internal crural ring) lies at the inner angle of the opening for the femoral vessels, between Poupart's ligament and the horizontal ramus of the pubis. The space is bounded within by the free border of Gimbernat's ligament (fan-shaped attachment of Poupart's ligament to the tubercle of the pubic bone), and without by the large vessels and the crural vein. The outer orifice of the crural canal corresponds with the loose connective tissue of the fascia lata (foramen ovale), through which the saphenous vein passes to enter into the femoral. The tendinous boundary of this opening has its concavity directed toward the middle line and is known as the falciform process.

A femoral hernia, after passing the internal crural ring, enters a space whose floor is formed by the pectineal fascia, which is bounded internally by Gimbernat's ligament, externally by the crural vessels, and in which for a short distance the upper continuation of the falciform process forms a resistant cover. If the free border of

this be passed, the hernia can push before it the less resistant lamina cribrosa and in this way it reaches the exterior through the foramen ovale. The coverings of a femoral hernia are thus fewer and thinner than those of an inguinal hernia. The hernial sac may, under circumstances, in emaciated subjects, lie just beneath the subcutaneous connective tissue. For this reason, in making the cutaneous incision, especially in further dissection at a depth, great care will be required. In general the radical operation for femoral hernia consists, after exposure of the hernial tumor and reposition of its contents, in ligating the sac at its neck and dividing it to the distal side of the ligature. To prevent recurrence the hernial opening is closed by suture. The incisions for exposure of the hernial tumor are generally made in a longitudinal direction over the greatest convexity of the tumor.

Fabricius clears the femoral hernia of fat lymphatic glands, and sutures the relaxed Poupart's ligament to the horizontal branch of the pubic bone as far back as possible.

Beginning at the pubic tubercle, Bassini unites Poupart's ligament with the pectineal fascia; further, the margin of the falciform fold is united with the pectineal fascia. Beginning with the uppermost suture, the threads are tied. The line of suture has the shape of an oblique *C*.

The conditions can be more comprehensively brought into view by inguinal exposure of the crural ring. In a communication made in the year 1882, E. Zuckerkandl first described his method. By means of an incision over Poupart's ligament dividing the abdominal wall, the crural ring is exposed. The incision is 8 or 9 cm. long and parallel with Poupart's ligament, like that made for ligation of the external iliac artery. The abdominal walls are divided down to the subperitoneal tissues, when the internal crural ring comes into view after detachment of the peritoneum.

Ruggi has devised a method of radical operation for crural hernia, based upon the same principles, which has

clinically proved successful in numerous instances. The inguinal method appears to be far superior to the crural methods hitherto employed with regard to inspection of the field of operation.

Radical Operation for Femoral Hernia by the Method of Ruggi.—A cutaneous incision is made from the pubic tubercle to the middle of and parallel with Poupart's ligament. If the margins of the wound are separated, the hernial tumor can be exposed. The hernial sac is opened separately, and the hernial contents are restored to the abdominal cavity. Now, the aponeurosis of the external oblique muscle is divided 0.5 cm. above Poupart's ligament in the direction of the cutaneous incision, and the spermatic cord or the round ligament of the uterus is retracted upward, together with the internal oblique and transversalis muscles. In the wound thus made the process of peritoneum passing to the femoral hernia is sought for in the preperitoneal cellular tissue above Poupart's ligament, and the neck of the hernia is grasped with blunt forceps, and drawn out of the crural canal into the wound. A ligature is then applied to the neck of the hernial sac, and this can be done at such a level that no trace is left of the funnel of peritoneum. Closure of the internal orifice of the inguinal canal is effected in such a manner that Poupart's ligament is united to the pubic ligament by sutures from the outer as well as the inner side. If the contents of the hernia can readily be replaced, exposure and opening of the hernial tumor in the oval foramen may be dispensed with, and from the outset the incision can be made through the external oblique, in order to grasp the hernial tumor from the inner aspect of the crural canal and to raise it from its bed. Then the hernial sac is ligated in the manner described and is removed. Closure of the hernial opening concludes the operation.

Umbilical Hernia, Radical Operation. **Operation for Incarcerated Omphalocele.**—The usual procedure consisted until recently in closure of the hernial opening by suture after opening the hernial tumor and replacement of the

intestine. Greater security against the recurrence of the hernia and a more thorough inspection during the operation are afforded by excision of the umbilical ring (*omphalectomy*, Condamin, Bruns). The umbilical region is surrounded by two elliptic incisions, each of which extends to the inner border of the rectus muscle and opens the abdominal cavity on either side of the hernial ring, so that the entire hernial tumor, together with the neck of the hernial sac, is removed. If, in addition, a portion of the sac is divided from the margin of the wound through the hernial opening, the entire contents of the hernia are exposed to view. In this way satisfactory scrutiny of the conditions present is possible, inasmuch as the abdominal viscera are rendered visible, both prior to their entrance into the hernia, as well as within the hernial sac. Adhesions that may be present are separated, and any existing strangulation can be freed in the open wound. After replacement of the intestines the abdominal wound is carefully approximated by interrupted sutures in three layers, the first including the serous membrane, the second the recti muscles and sheaths, and the third the skin.

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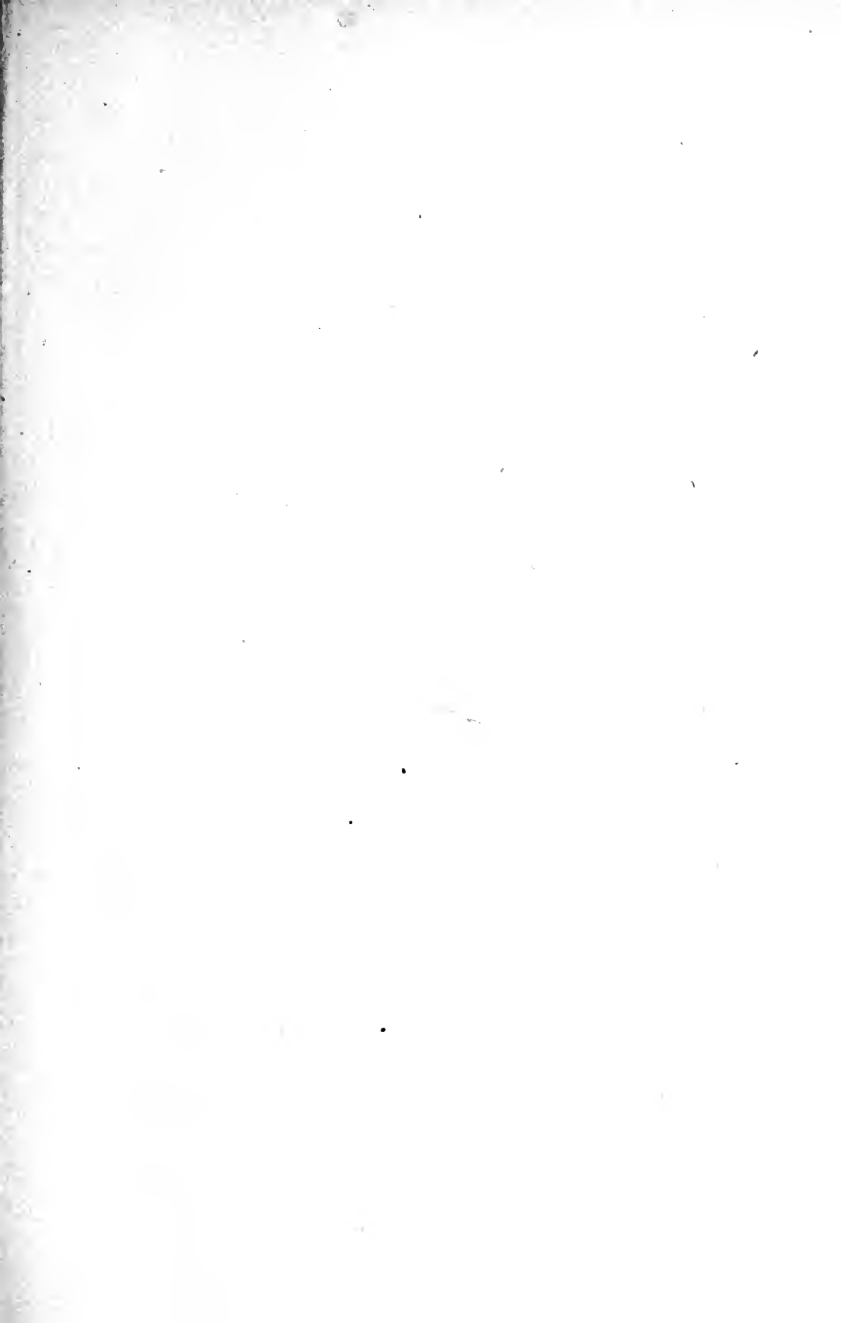
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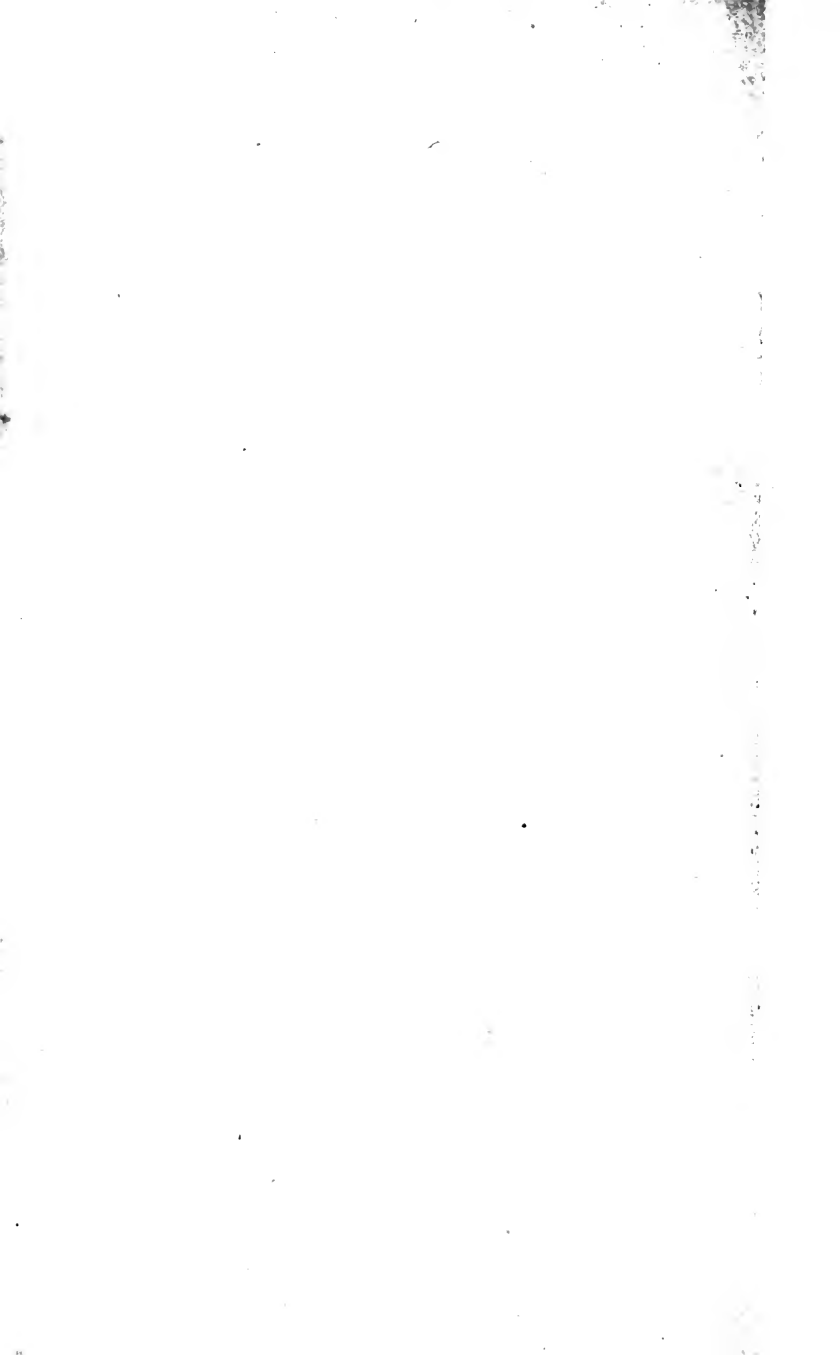
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